Census 2000 Testing, Experimentation,
and Evaluation Program

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COVERAGE MEASUREMENT FROM THE PERSPECTIVE OF MARCH 2001 A.C.E.

Quality assurance procedures were applied throughout the creation of this report.

This topic report integrates findings and provides context and background for interpretation of results from Census 2000 evaluations, tests, and other research undertaken by the U.S. Census Bureau. It is part of a broad program, the Census 2000 Testing, Experimentation, and Evaluation program, designed to assess Census 2000 and to inform 2010 Census Planning.

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U S C E N S U S B U R E A U
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CONTENTS

LIST OF TABLES

1. Introduction

The Census 2000 Testing, Experimentation, and Evaluation Program provides measures of effectiveness for the Census 2000 design, operations, systems, and processes and provides information on the value of new or different methodologies. The results and recommendations from these analyses provide valuable information crucial to planning the 2010 Census. By providing measures of how well Census 2000 was conducted, this program fully supports the Census Bureau's strategy to integrate the 2010 planning process with ongoing Master Address File/TIGER enhancements and the American Community Survey. The purpose of the report that follows is to synthesize results from related Census 2000 evaluations, experiments, and other assessments to make recommendations for planning the 2010 Census. Census 2000 Testing, Experimentation, and Evaluation reports are available on the Census Bureau's Internet site at: http://www.census.gov/pred/www/. The reports and documentation of the Executive Steering Committee for the A.C.E. Policy (ESCAP) are located at: http://www.census.gov/dmd/www/EscapRep.html, http://www.census.gov/dmd/www/EscapRep2.html, and http://www.census.gov/dmd/www/ace2.html.

The Census Bureau conducted the Accuracy and Coverage Evaluation (A.C.E.) expecting it could be used to adjust the Census 2000 results for all non-apportionment purposes if it improved the census data. The original March 2001 A.C.E. estimates became available in time to correct the Census 2000 redistricting files. On March 1, 2001, the Census Bureau released the "Report of the Executive Steering Committee for Accuracy and Coverage Evaluation Policy" which reported that "The Executive Steering Committee for A.C.E. Policy (ESCAP) is unable to conclude, based on the information available at this time, that the adjusted Census 2000 data are more accurate for redistricting. Accordingly, ESCAP recommends that the unadjusted census data be released as the Census Bureau's official redistricting data." (ESCAP, 2001.)

The ESCAP noted the difference between the A.C.E. estimate, a 3.3 million net undercount, and Demographic Analysis (DA) results, a 1.8 million net overcount. The Census Bureau conducted further evaluations over the next six months to examine this difference and determine if Census 2000 data, other than redistricting data, should be corrected. Two planned A.C.E. evaluation programs, the Matching Error Study (MES) (Bean, 2001) and the Evaluation Followup (EFU) (Raglin and Krejsa, Report 3, 2001), identified errors in the A.C.E. The Person Duplication Study (Mule, Report 20, 2001) used computer matching to identify duplicates across the entire country and Feldpausch (2001) examined the enumeration status assigned to the E sample for these duplicates. Adams and Krejsa (2001) re-coded the enumeration status to reduce any operational and procedural errors in the original enumeration status coding. Additional evaluations addressed other concerns (ESCAP II, 2001) including A.C.E. balancing, contamination, and missing data. The DA estimates were investigated further resulting in revisions (particularly migration estimates) and revised DA estimates. (Robinson, Report 1, 2001.) Due to uncertainty whether all errors associated with the A.C.E. (e.g. duplication error) were captured, results from the total error model designed to synthesize individual errors and the

associated loss function analysis were not used. (Petroni, 2001.)

On October 17, 2001, the Census Bureau released "Report of the Executive Steering Committee for Accuracy and Coverage Evaluation Policy on Adjustment for Non-Redistricting Uses" which reported,

> The Executive Steering Committee for A.C.E. Policy (ESCAP) recommended on March 1, 2001 that unadjusted census data be used for redistricting. After assessing considerable new evidence, ESCAP now recommends that unadjusted Census 2000 data also be used for non-redistricting purposes. The effect of this new evidence is that the Accuracy and Coverage Evaluation (A.C.E.) overstated the net undercount by at least 3 million persons. The cause of this error was that the A.C.E. failed to measure a significant number of census erroneous enumerations, many of which were duplicates. This level of error in the A.C.E. measurement of net coverage is such that the A.C.E. results cannot be used in their current form. This finding of substantial error, in conjunction with remaining uncertainties, necessitates that revisions, based on additional review and analysis, be made to the A.C.E. estimates before any potential uses of these data can be considered. The Census Bureau will release the remaining Census 2000 data products, post-censal estimates, and survey controls using unadjusted data. It is, however, reasonable to expect that further research and analysis may lead to revised A.C.E. estimates that can be used to improve future post-censal estimates. (ESCAP II, 2001.)

Coupled with the revisions to the DA estimates, the inconsistency with DA was explained by the failure of the A.C.E. to measure a large number of census erroneous enumerations. The earlier concerns in A.C.E. with balancing, contamination, and missing data were also resolved. The level of other errors was believed to be small by comparison and therefore was not a major factor in the second ESCAP decision. (Hogan et al., 2002; Mulry and Petroni, 2002; ESCAP II, 2001.)

In October 2001, the Census Bureau released approximate estimates of the undercount for three race/Hispanic origin groups. (Thompson et al., 2001.) These "Revised Early Approximations" corrected estimates of erroneous enumerations for census duplicates and for other erroneous enumerations identified in the A.C.E. evaluations but not in the full A.C.E. E sample. This illustrated the correction effects on net undercount estimates and on possible coverage differences. The Census Bureau later used the same methods and data to expand the calculations to seven race/Hispanic origin groups. (Fay, 2002; Mule, 2002.) These preliminary estimates showed, like the revised DA results, a small net undercount and that the differential undercount was reduced, but not eliminated. These results only provided data at the national level for broad population groups. Furthermore, these preliminary approximations were based on a small subset of A.C.E. data and only partially corrected for errors in measuring erroneous enumerations using Fay's lower bound. (Fay, 2001, Fay, 2002.) Potential errors in measuring omissions were not

accounted for.

Even though the ESCAP recommended twice **NOT** to correct the census counts, they had concerns about differential coverage in Census 2000. They thought further research on revised coverage estimates could be used to improve the post-censal estimates. Work on revised estimates would provide a better understanding of Census 2000 coverage error that could be used to improve the 2010 Census and develop better methods for the 2010 coverage measurement program. Hence, work began on revising the A.C.E. estimates to correct for detected errors. The results can be found in the "Technical Assessment of A.C.E. Revision II". (U.S. Census Bureau, 2003.)

The following report is divided into three sections discussing the comparison of March 2001 A.C.E. coverage estimates with Demographic Analysis, March 2001 A.C.E. person estimates, and A.C.E. housing unit estimates. The conclusions and recommendations are based on the March 2001 A.C.E., work done prior to the A.C.E. Revision II. The recommendations for the 2010 Census assume the Census Bureau decides to do a similar approach to undercount estimation using a coverage measurement survey. The research and results from A.C.E. Revision II are out of scope for this report due to resource constraints. The coverage estimates from A.C.E. Revision II are considered better than the March 2001 A.C.E. estimates. In fact the earlier coverage estimates are considered flawed and are not indicative of the Census 2000 coverage error. To avoid misunderstandings, earlier flawed estimates are referred to as March 2001 A.C.E. in the remainder of the report. A list of the evaluations and other reports used in this topic report are in the references section. All evaluations discussed in this report are based on the March 2001 A.C.E.

The housing unit coverage estimates did not have the exhaustive evaluation that was conducted for the person estimates and A.C.E. Revision II did not attempt to revise the housing unit coverage estimates. The difficulties in identifying residence in the person estimates should not affect our ability to identify the existence of a housing unit on Census Day. However, to the extent not identifying erroneous census enumerations or duplicates was large for the household, then this could have affected the reliability of some of the housing estimates by householder characteristics such as occupancy status, race, or owner status.

1.1 The Census Design

Census 2000 paralleled the design of other recent U.S. Decennial Censuses in many respects. Census 2000 attempted to enumerate all people living in the United States on April 1, 2000. Most of the population was enumerated by means of mailback questionnaires delivered to their homes in March 2000. The mailback questionnaire asked, "How many people were living or staying in this house, apartment, or mobile home on April 1, 2000?", then asked respondents to answer questions for each person. Respondents were given guidance about whom to include ("foster children, roomers, or housemates"; "people staying here on April 1, 2000 who have no other permanent place to stay"; "people living here most of the time while working, even if they

have another place to live") and whom to exclude ("college students living away while attending college"; "people in a correctional facility, nursing home, or mental hospital on April 1, 2000" ; "Armed Forces personnel living somewhere else"; "people who live or stay at another place most of the time"). People who did not respond by mail were enumerated in person by enumerators who visited their homes during *Nonresponse Followup* (NRFU) between April 27 and June 26. In most cases, NRFU interviewers spoke to a member of the nonresponding household, but after they had attempted repeatedly to contact nonresponding households, they were allowed to obtain basic data about the residents from proxy respondents, such as neighbors, landlords, or other nonhousehold members. (Martin, Fay, and Krejsa, November 2002.)

People in *group quarters* (such as college dormitories, homeless shelters, and nursing homes) were enumerated in separate operations at the facilities, where enumerators listed the names of the people living or staying there and left Individual Census Reports for each person to complete. Enumerators picked up the forms and, if necessary, conducted interviews with nonrespondents. (Martin, Fay, and Krejsa, November 2002.)

Two basic errors affected the population total from the census: *omissions* of persons who should have been counted, and *erroneous enumerations* of persons who should not have been counted, such as fictitious persons or persons counted more than once. Persons were considered omitted if they were not counted in the right geographic area and erroneously included if they were incorrectly counted in a different area. The A.C.E. defined omissions and erroneous enumerations with respect to a relatively small geographic area called the search area, which was typically a block or group of blocks and in some cases blocks immediately surrounding the sample blocks. Under this approach, people counted in the wrong block were classified as omitted from where they should have been counted and erroneously enumerated where they were counted. (Martin, Fay, and Krejsa, November 2002.)

In the decennial census, the Census Bureau attempted to enumerate each person at his or her "usual residence" as of April 1st, defined as the place where a person lived or slept most of the time. The basic usual residence principle was based on 31 residence rules which apply to special circumstances: for example, people who were staying in most types of institutional settings or other group quarters (e.g., dormitory, shelter, or nursing home) on April 1st were enumerated there, even if they also had another residence. The instructions on the census form described the most common living situations, but respondents often find the rules self-contradictory and the terminology confusing. (Martin, Fay, Krejsa, 2002.) Also, some types of noninstitutional group quarters allowed the respondent to indicate they should have been counted at their usual home.

1.2 Coverage Measurement

The A.C.E. attempted to measure net undercount through a sample survey. Conceptually, an independent sample of the population, the *P sample,* was used to estimate the omissions. A sample of census enumerations, the *E sample,* was selected from census enumerations to determine erroneous enumerations. Together they were used to estimate the net coverage error.

Omissions and erroneous enumerations are defined within the search area. They are not meant to be estimates of gross errors. Following the precedent of the 1990 coverage study, the A.C.E. geographically overlapped the P sample and E sample by selecting them from the same sample of blocks. See the "Technical Documentation for March 2001 Estimates" in Kostanich (2003) for more details.

The housing unit stage of A.C.E. was a combination of sampling and operational activities which resulted in the selection of 300,000 P-sample housing units from the 50 states and the District of Columbia, excluding areas of remote Alaska. The selection was independent of any census operation. A detailed description of the A.C.E. sampling plan can be found in ZuWallack, Salganik, Cromar, and Mule (2000).

The A.C.E. comprised several operations, but five primary operations are critical in the analysis that follows. For more details see Childers (2001). The "Glossary of Specialized and Technical Terms Used in the ESCAP Report and Supporting Documents" is a helpful source for defining terms used throughout this report. (ESCAP II, Chapter VIII, 2002.)

- An initial interview of P-sample households was conducted by phone (April 24 through June 13) or by personal visit (June 18 through September 11), using a computer-assisted instrument on a laptop. The interview established both the current residents and, if different, the Census Day residents of the sampled housing units. The interview was conducted only with a household member for the first three weeks of interviewing. If the interview with a household member was not successful after three weeks, an interview with a proxy respondent, which is a nonhousehold member, was attempted. The Computer Assisted Personal Interview (CAPI) instrument was designed to obtain a roster of the current residents and the residents on Census Day, measure their demographic characteristics such as sex, age, race, and ethnicity, and determine whether each identified Census Day resident should have been included in the census in the housing unit or somewhere else.

- In October through November 2000, P-sample Census Day residents[1] were matched to the census. If the A.C.E. interview established the Census Day address for a P-sample person and if that person matched a person enumerated in the Census, then the P-sample person was considered matched to the census and the corresponding E-sample person classified as a correct enumeration.

- Some categories of P-sample people who did not match to the census were sent to the *A.C.E. Person Followup* (PFU) because the Census Bureau was not absolutely certain about the information provided in the original interview. The categories included not

[1] The Census Day residents are both the nonmovers and the outmovers. Nonmovers lived at the sample address on Census Day and at the time of the A.C.E. interview. Outmovers lived there on Census Day, but not on the day of the A.C.E. interview.

matched people from proxy interviews, from conflicting households[2], and from households where some people matched. The followup interview identified P-sample people who were not residents of the housing unit on Census Day who were then removed from the P sample. The followup interview also included all not matched E-sample cases in order to identify erroneous enumerations. Because they were matched, the majority of census enumerations in the E sample required no separate field work. Followup interviews were conducted in person from October 19 through November 21, 2000, using a questionnaire preprinted with name and address information about the sample household. Interviews were accepted with non-household proxies if knowledgeable household respondents were not found after six contact attempts on different times on different days.

- Despite extensive attempts to interview every housing unit in the P sample, there were households for which the Census Bureau simply could not obtain information. To account for the missing information from these households not interviewed, the Census Bureau applied a noninterview adjustment to interviewed units. Furthermore, although most P-sample people were assigned a residence and match status, and E-sample people an enumeration status, a small number of people remained with one or more of these statuses unresolved. That is, the Census Bureau may not have been sure if a person was actually a resident of the housing unit on Census Day, or if another person was correctly enumerated in the census. For these people with an unresolved status, the Census Bureau assigned a probability of having lived in the block cluster on Census Day, having matched, or having been correctly enumerated. See Cantwell et. al. (2001) for a discussion of the A.C.E. missing data procedures.

- The results of matching the P sample and E sample were used to produce population estimates using Dual System Estimation(DSE). The DSE is a technique that estimates the true population using estimates of the number of census enumerations correctly included in the census from the E sample and the ratio of the number of people who should have been included and were correctly included in the census to the total population from the P sample. See Sekar and Deming (1949), Wolter (1986), and Hogan (1993) for more information about Dual System Estimation. Estimates of the population are made within estimation cells, called post-strata defined by geography and demographic variables. The sum of the estimate of the population across estimation cells is the Dual System Estimate of the population. The net undercount is the difference in the Dual System Estimate of the population and the number of people counted in the census. The percent net undercount is the net undercount divided by the number of people counted in the Dual System Estimate of the population.

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[2] A conflicting household refers to the households at a matched, non-vacant address or individual housing unit, where the A.C.E. household and census household do not contain any matched or possibly matched people.

Table 1 compares percent net undercount estimates from the flawed March 2001 A.C.E. and the 1990 Post Enumeration Survey (PES) for major groups. The A.C.E. estimates were later revised. (See U.S. Bureau of the Census, 2003.) Comparisons here show results before those revisions. The DSE shows Census 2000 undercounted the national household population and that undercounts differed by population subgroups. Relative to the 1990 census, Census 2000 showed an apparent improvement in the overall percent net undercount and the differential undercounts of certain population groups. The national percent net undercount of the household population for Census 2000 is 1.18 percent (standard error, 0.13 percent) compared to the 1990 Census 1.61 percent (standard error, 0.20 percent). The Census 2000 coverage showed differential undercount rates among the race/origin domains, tenure, and age/sex groups. The percent net undercount for the Non-Hispanic Black and Hispanic domains is lower for Census 2000 compared to the 1990 Census, which results in a differential undercount reduction relative to the Non-Hispanic White and "Some other race" domain. The Census 2000 percent undercount for Non-Owners and for children ages 0 to 17 is lower than in 1990. (Davis, 2001.)

Table 1: Percent Net Undercount for Major Groups: March 2001 A.C.E. and 1990 PES

March 2001 A.C.E.*			1990 PES		
Characteristic	Net Undercount (Percent)	Standard Error (Percent)	Net Undercount (Percent)	Standard Error (Percent)	Characteristic
Total	1.18	0.13	1.61	0.20	**Total**
Race/Origin Domain**					**Race/Origin Domain**
Non-Hispanic White	0.67	0.14	0.68	0.22	Non-Hispanic White & Other
AI Off Reservation	3.28	1.33			
Non-Hispanic Black	2.17	0.35	4.57	0.55	Black
Hispanic	2.85	0.38	4.99	0.82	Hispanic
Non-Hispanic Asian	0.96	0.64	2.36	1.39	Asian or Pacific Islander
Hawaiian or Pacific Islander	4.60	2.77			
AI On Reservation	4.74	1.20	12.22	5.29	AI On Reservation
Tenure					**Tenure**
Owner	0.44	0.14	0.04	0.21	Owner
Non-Owner	2.75	0.26	4.51	0.43	Non-Owner
Age/Sex					**Age/Sex**
0-17	1.54	0.19	3.18	0.29	0-17
18-29 Male	3.77	0.32	3.30	0.54	18-29 Male
18-29 Female	2.23	0.29	2.83	0.47	18-29 Female
30-49 Male	1.86	0.19	1.89	0.32	30-49 Male
30-49 Female	0.96	0.17	0.88	0.25	30-49 Female
50+ Male	-0.25	0.18	-0.59	0.34	50+ Male
50+ Female	-0.79	0.17	-1.24	0.29	50+ Female

2000 net undercount is for household population.
1990 net undercount is for the PES universe which included noninstitutional, nonmilitary Group Quarters in addition to the household population. As a result, the 1990 estimates may differ from the Committee on Adjustment of Postcensal Estimates (CAPE) results. See Bryant et al. (1992) and Thompson (1992).
The 1990 Hispanic domain excludes Blacks, Asian or Pacific Islanders, and American Indians on Reservation.
A negative net undercount denotes a net overcount.
* These estimates are considered to be unacceptable and were subsequently revised as explained in U.S. Bureau of the Census (2003).
**See Davis (2001) for definitions of Race/Origin Domains.

1.3 Differences in 1990 Post Enumeration Survey and 2000 Accuracy and Coverage Evaluation

The 1990 PES and 2000 A.C.E. were based on the same methodology, but there were differences. The major differences are as follows:

- The sample was 166,000 housing units in 1990 and 300,000 in 2000.

- In 1990 the universe was housing units and noninstitutional nonmilitary group quarters. The universe for 2000 was housing units only.
- In 1990 large block subsampling was a clerical operation. In 2000 housing unit matching was conducted before the interviewing allowing the large block subsampling to be done by computer.
- The interview was a paper operation in 1990 and in 2000 the interview was computer assisted.
- In 1990 the P sample was the current residents[3] and the Census Bureau matched the inmovers to their Census Day address. In 1990 the search area was the sample blocks and one ring of surrounding blocks in urban areas, two rings of surrounding blocks in rural areas, and in a larger area of blocks for the most rural areas of the country. In 2000 the P sample was the Census Day residents and they were matched to the census enumerations in the block cluster and surrounding blocks for selected clusters. (This is referred to as the Targeted Extended Search.)
- In 1990 all whole household P-sample not matched people were sent for a followup interview. In 2000 P-sample not matched people from housing units interviewed with household members were not sent for followup.

2. Demographic Analysis: Comparison with March 2001 A.C.E. Coverage Estimates

Demographic Analysis (DA) is a well-developed tool for evaluating population coverage. The DA is an analytic approach that has been extensively used at the Census Bureau to measure coverage of the national population in every census since 1960 (Siegel and Zelnik, 1966; Fay et. al., 1974, 1988; Robinson et. al., 1993; Robinson, March 2001.)

Demographic Analysis represents a macro-level approach for estimating the net undercount by comparing aggregate sets of data or counts. The demographic approach differs fundamentally from the survey-based A.C.E. The traditional DA population benchmarks are developed for the census date by analyzing various types of demographic data essentially independent of the census, such as administrative statistics on births, deaths, authorized international migration, and Medicare enrollments, as well as estimates of legal emigration and net unauthorized immigration. The difference between the Demographic Analysis benchmarks and the census count provides an estimate of the census net undercount. Dividing the net undercount by the DA benchmark provides an estimate of the net undercount rate. (Robinson, March 2001.)

Demographic Analysis estimates were inconsistent with March 2001 A.C.E. estimates. The Census Bureau expected demographic analysis to posit a higher estimate of the total population than the March 2001 A.C.E. because of the presence of correlation bias, and that the two

[3] The current residents are the people who lived in the housing unit at the time of the PES interview in 1990, which are the nonmovers and inmovers. The nonmovers lived at the sample address on Census Day and at the time of the PES interview. The inmovers did not live there on Census Day but moved to the address before the date of the PES interview.

estimates would generally agree on the coverage of certain populations. Instead, the Base DA estimates[4] were lower than both the Census 2000 population counts and the March 2001 A.C.E. estimates. In response, the Census Bureau developed Alternative DA estimates by doubling the unauthorized immigration assumed in the 1990s[5]. Doing so yielded a number of foreign born for 2000 consistent with the March 2000 Current Population Survey.[6] Still, the Alternative DA estimated numbers produced in February 2001, were significantly lower than the March 2001 A.C.E. The Alternative DA indicated that Census 2000 undercounted the population by 0.32 percent, while the March 2001 A.C.E. produced a net undercount estimate of 1.15 percent.[7]

The Census Bureau concluded that the inconsistent estimates of the total national population derived from one or more of three explanations:

- All available 1990 census data, including the census results, the 1990 coverage measurement survey, and the 1990 DA estimates, significantly understated the Nation's population, but Census 2000 found this previously unenumerated population.

- DA underestimated population growth between 1990 and 2000.

- The March 2001 A.C.E. overestimated the Nation's population.

Further research on demographic analysis focused on two main topics: international migration and measurement of vital events like births and deaths. (ESCAP II, 2001.)

2.1 International Migration

The Census Bureau regarded the international migration assumptions as the most uncertain component in the demographic analysis estimates completed by March 1, 2001. Research after March 1, 2001 focused primarily on those international migration components that are less well measured (e.g., emigration, temporary migration, and unauthorized migration). It also included research into legal immigration and the demographic characteristics of migrants used in the

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[4] Base DA estimates refer to the Demographic Analysis estimates produced in January 2001 by the Census Bureau for Census 2000.

[5] The process of revising the Demographic Analysis estimates made use of Census 2000 long form data to revise estimates of the foreign born population.

[6] The March Current Population Survey was reweighted using the Census 2000 counts by age, race, sex, and Hispanic origin for this comparison.

[7] This figure differs from the 1.18 percent usually quoted for the March 2001 A.C.E. because the A.C.E. and DA estimate different populations. The base of the DA percent is the total population, while the base of the A.C.E. percent is the household population, which excludes group quarters.

March 2001 DA estimates.

Part of the analysis involved discussions with independent experts on demographic analysis and international migration. Participants of a March 20, 2001 meeting explained how the DA estimates differed from the March 2001 A.C.E. estimates, and discussed how to prioritize short-term and long-term research activities. Attendees included experts from the statistical community, academia, state agencies, the Census Bureau's advisory committees, professional organizations, and international organizations. These experts, almost unanimously, recommended focusing on components of international migration because of the uncertainty of associated assumptions and estimates.

The Census Bureau sought expert help on September 24, 2001, after completing the original research activities (validation of the 1990 estimates and updated 2000 estimates) that produced the revised DA estimates. Although these experts generally agreed with the methods used to calculate components of international migration, they had concerns about the assumptions regarding the undercount of international migrants. Specifically, they believed the undercount assumption of 15 percent for unauthorized migrants, which the Revised DA incorporated, was too high, especially given the March 2001 A.C.E. undercounts for other hard-to-enumerate groups. In addition, they urged renaming the residual migrant category as the residual foreign-born, or separating the residual foreign born into known components ("quasi-legal" migrants) and the implied unauthorized migrant population. Subsequent sensitivity analysis incorporated both of these suggestions.

The sensitivity analysis of assumptions about various components of the foreign-born population showed that the total number of foreign born did not vary enough to have much effect on the total population DA estimate. For example, the lower bound assumption of 3.3 percent net undercount of the foreign-born equated to a population of 281.3 million, or more than three million people lower than the March 2001 A.C.E. total population. The upper bound assumption of 6.7 percent was consistent with a 282.5 million population, which is still more than two million lower than the March 2001 A.C.E. total population. These results led the Census Bureau to conclude that the Revised DA was an appropriate benchmark for assessing Census 2000 and the March 2001 A.C.E. estimates. (ESCAP II, 2001.)

2.2 Measurement of Vital Events

Other research examined the remaining assumptions underlying the DA components of change, including the birth, death, and Medicare components. Although death and the elderly population size estimates did not change much, this research changed the estimates of historical births by revising the assumptions about registration completeness of births since 1968. The previous DA estimates assumed a 99.2 percent (the 1968 level) registration of all births in years since 1968 (the last year of testing birth registration completeness). For the Revised DA estimates, registration completeness was assumed to gradually reach 100 percent by 1985 (the first year natality statistics were reported electronically from all the States), and remained at 100 percent

through 2000. This revision lowered the estimated number of births for 1968-2000 by 715,000, which lowered the Revised DA estimate of the total population in 2000 by the same number. (Robinson, October 2001.)

2.3 Results of Revised DA

The research undertaken between March and October allayed two fundamental concerns: (1) the Alternative DA did not capture the full growth of the population between 1990 and 2000, and (2) the 1990 DA was lower than the true population. The research effect on immigration, births, and deaths led to Revised DA estimates, produced in September 2001, which were slightly different from the Alternative DA. The inconsistency between the Alternative DA and the March 2001 A.C.E. estimates did not result from unexplained problems in DA. These results led the Census Bureau to conclude that the March 2001 A.C.E. overestimated the Nation's total population.

The Revised DA lowered the estimated net undercount rates from 1.85 to 1.65 percent in 1990, and from 0.32 to 0.12 percent in 2000, but did not alter the DA finding that the estimated net undercount rate in 2000 was substantially lower than in 1990. (Robinson, October 2001.) The Revised DA continued to estimate a lower net undercount than the March 2001 A.C.E., and was very close to the Alternative DA estimate used in March. The Revised DA estimated a net undercount of 0.3 million, or 0.12 percent, compared with the March 2001 A.C.E. estimate of a net undercount of 3.3 million, or 1.15 percent. Population totals from the Base DA, Alternative DA, and Revised DA, along with the Census 2000 counts and the March 2001 A.C.E. estimates, are shown in Table 2.

Table 2: Resident Population Totals from Census 2000, Demographic Analysis, and the March 2001 A.C.E.: April 1, 2000

Source	Total Population
Base DA	279,598,121
Census 2000	281,421,906
Revised DA (Revised Registration Completeness Assumption)	281,759,858
Alternative DA (Double Unauthorized Immigration)	282,335,711
March 2001 A.C.E.*	284,683,782

* This estimate is considered to be unacceptable and was subsequently revised as explained in U.S. Bureau of the Census (2003).

As shown in Table 3 (see Appendix A for a note regarding inconsistencies in race classifications between DA, the 2000 A.C.E., and the 1990 PES), the Revised DA implied a greater reduction than the March 2001 A.C.E. in estimated net undercount in Census 2000 compared with the 1990 census. The revised DA reduced the estimated net undercount rate by 1.53 percentage points, from 1.65 percent in 1990 to 0.12 percent in 2000. In contrast, the March 2001 A.C.E. estimate of 1.15 percent net undercount in 2000 was 0.43 percentage points lower than the 1.58 percent estimate in the 1990 PES. Additionally, both DA and the March 2001 A.C.E. estimated a reduction in the net undercount rates of Black and NonBlack children compared with 1990. Both

methods also estimated a reduction in the net undercount rates of adult Black men and women.

The revised DA and March 2001 A.C.E. estimates continued to disagree. The DA found a reduction in the estimated net undercount rates of NonBlack men and women in Census 2000 compared with the rates of previous censuses. The March 2001 A.C.E. indicated no change or a slight increase in estimated undercount rates for NonBlack adults as a group.

Table 3: Percent Net Undercount, by Race*, Sex, and Age: 1990 and 2000

	Revised Demographic Analysis		PES/A.C.E	
Category	**1990**	**2000**	**PES 1990**	**March 2001 A.C.E.****
Total	1.65	0.12	1.58***	1.15***
Black	5.52	2.78	4.43	2.07
0-17	5.27	1.3	7.05	2.92
Male, 18+	9.57	7.15	3.76	2.10
Female, 18+	2.05	0.07	2.64	1.28
NonBlack	1.08	-0.29	1.18	1.01
0-17	1.12	0.54	2.46	1.27
Male, 18+	1.74	0.17	1.19	1.43
Female, 18+	0.44	-1.27	0.34	0.44

A minus sign denotes a net overcount.
*See appendix A for a note regarding inconsistencies in race classifications between DA, the March 2001 A.C.E., and the 1990 PES.
**These estimates were determined to be unacceptable and were subsequently revised as explained in U.S. Bureau of the Census (2003).
***These figures differ from the 1.61 and 1.18 percents quoted in Table 1 because the A.C.E. and DA estimate different populations. The base of the DA percent is the total population, while the base of the A.C.E. percent is the household population, which excludes group quarters.

Demographic analysis provided evidence that correlation bias[8] was not reduced between 1990 and 2000. Comparisons of the DA and March 2001 A.C.E. sex ratios (men per 100 women) showed that correlation bias in the survey estimates was not reduced for Black men between 1990 and 2000. The March 2001 A.C.E. sex ratios for Black adults were much lower than the expected sex ratios based on DA, implying that the March 2001 A.C.E. did not capture the high undercount rate of Black men relative to Black women. The size of this bias was about the same

[8] Correlation bias refers to the tendency for census enumerated people to be more likely included in the A.C.E. than people missed in the census. The DA sex ratios and March 2001 A.C.E. data are used to produce correlation bias estimates for males. Adult females are assumed to have no correlation bias.

as in the 1990 coverage measurement survey. (ESCAP II, 2001.)

The DA estimates do have a few limitations. First, the major DA estimates are available only at the national level and only for two broad race categories: Black and Nonblack (All Other Races Combined). Another concern regarding DA estimates is the uncertainty of the measured undercounts. The aggregate administrative data and estimates used to construct the DA benchmarks are corrected for various types of errors. There are assumptions in this estimation process, some of which can be validated and some of which are based on quite limited information. Third, the race categories in the DA estimates largely reflect the race assigned in the particular administrative record at the time of the event (birth, death, or enrollment in Medicare). The DA estimates of net undercount are biased to the extent that people who are classified as a particular race in DA (e.g., Black) reported a different race in the A.C.E. Fourth, the DA covers the total population while the A.C.E. is limited to the household population. The difference in the universe is the group quarters (GQ) population. The GQ population is included in the DA estimates, and cannot be separated, but the GQ population is excluded from the A.C.E. universe. (Robinson, October 2001).

The Census Bureau should continue to use DA as a coverage evaluation tool. For the 2010 Census, the Census Bureau should also investigate ways to measure uncertainty in the DA estimates of undercount and to expand DA estimate to more race/ethnicity groups.

3. March 2001 A.C.E.: Person Coverage

We begin the examination of person coverage by summarizing recommendations for sampling and estimation and evaluation studies and recommendations for person interviewing. We follow this with summarizations of basic results or evaluations for specific error sources: erroneous enumerations, census omissions, balancing, correlation, conditioning, reinstated late additions, and Census 2000 imputations. For each error source, we also provide recommendations for future consideration.

3.1 Sampling and Estimation

"In January 1999, the Supreme Court ruled against the use of sampling for congressional apportionment. (Department of Commerce v. House of Representatives, 525 U.S. 316, 119 S. Ct. 765 (1999).)" (U.S. Census Bureau, December 2002.) This changed the Census Bureau's plans for the coverage measurement survey. The A.C.E., a subsample of the Integrated Coverage Measurement (ICM) survey, replaced the ICM. The ICM would have produced estimates of the population for each state directly from the state sample with sufficient reliability for apportionment. "The A.C.E. was a quality check to evaluate the census coverage and possibly correct for net coverage, but could not be used for apportionment." (U.S. Census Bureau, December 2002.)

The timing of the decision against sampling for apportionment impacted sampling and estimation

in three key ways.

- The Census Bureau did not have time to redesign the A.C.E. sample to meet the production schedule, so the Census Bureau designed the A.C.E. sample based on the ICM using a double sampling[9] approach.

- The multi-phase sampling meant that the Census 2000 Dress Rehearsal variance estimation procedures had to be discarded and new procedures researched and developed.

- The state-based post-stratification plan had to be discarded and a national post-stratification researched and developed. (U.S. Census Bureau, December 2002.)

Below is a summary of assessments of the major A.C.E. sampling (U.S. Census Bureau, October 2002) and estimation steps in Census 2000 (U.S. Census Bureau, December 2002) and suggestions for the future. These assessments were obtained by the Decennial Management Division through discussions with key professional staff involved in sampling and estimation planning and implementation. Except for the missing data compensation step, no formal evaluations were conducted.

The major sampling and estimation steps for the 2000 A.C.E. are:

- Sampling
- Weight trimming
- Missing data compensation
- Dual system estimation
- Synthetic estimation
- Variance estimation.

3.1.1 Sampling

The P sample contained approximately 300,000 housing units in the 50 states (excluding areas of remote Alaska) and the District of Columbia.

For planning the 2010 Census, the Census Bureau should consider the following recommendations:

- Explore the pros and cons of a double sampling approach from the perspective of estimation and field concerns. Consider if the Census Bureau should develop a design allowing the flexibility to apply either a state or national design in anticipation of the possible need to change designs as was done in Census 2000.

[9] Double sampling refers to the subselection of the final sample from a preselected larger sample.

- Do additional analysis to obtain better measures of size of census blocks, critical information for the sample design. Improved measures of size makes possible better control of workloads, weights, and variances.

- Use the Census 2000 method or a similarly defined method for sampling small census blocks, those with zero to two housing units. This results in variance estimation efficiencies and reduces the effect the small block clusters have on the estimates. (U.S. Census Bureau, October 2002.)

3.1.2 Weight Trimming

The Census Bureau designed A.C.E. weight trimming to reduce sampling weights for clusters that would have an extreme influence on the dual system estimates and variances. They trimmed the weight for one cluster. (Mule, American Statistical Association, 2001.)

For the 2010 Census, the Census Bureau should consider these recommendations:

- Build a threshold standard into the weight trimming procedure. If the total weight to be trimmed or the change in the mean square error by doing the trimming are below a given threshold, then the weight trimming would not be implemented.

- Control weights at the post-stratum level rather than at the cluster level. In Census 2000, only one cluster needed trimming. However, at the post-stratum level, a post-stratum had several clusters with high weights.

- Schedule weight trimming during dual system estimation instead of before missing data processing to allow the Census Bureau to take into account the effect of weight trimming on the Dual System Estimates. (U.S. Census Bureau, December 2002.)

3.1.3 Missing Data

Missing data occurred in the A.C.E. if, after all followup attempts, there remained households not interviewed or households with portions of the person data missing, such as age or race. Sometimes the missing item might have been the status of whether a person matched, was a resident on Census Day, or was correctly enumerated. The Census Bureau used statistical models to account for missing data. As shown below, the level and pattern of missing data in the March 2001 A.C.E. was comparable to that of the 1990 PES. The effect of the missing data on the overall March 2001 A.C.E. quality was similar to that experienced by the 1990 PES and documented in the P studies. (Mack et. al., 1991; Gbur, 1991; West, 1991.)
Additional statistical models to account for missing data were developed to assess the effect on the estimates of using alternative models. (Keathley, Kearney, and Bell, 2001.)

Imputed demographic characteristics used to account for missing post-stratification variables

result in increased classification error as well as synthetic error and possibly contribute to correlation bias. High levels of missing data, particularly for match, residence, or enumeration status[10], also increase variance. The Census Bureau did not evaluate how this type of missing data increases variance because the measure of sampling variance largely picked up this component.

Two important changes for the Census 2000 could have affected missing data rates. First, the level of missing data in the A.C.E. interview could have been higher because of a change in how the Census Bureau treated movers. In 1990, the Census Bureau only needed to interview the current residents, whereas in Census 2000, interviewers needed information about the current (A.C.E. Interview Day) residents and the Census Day residents. On the other hand, the A.C.E. eliminated the need to geographically code the Census Day address of inmovers, thus eliminating one potential source of missing data. Second, the Computer Assisted Personal Interview (CAPI) instrument kept the interviewer on the correct set of questions and allowed for tight managerial control.

The March 2001 A.C.E. missing person demographic characteristics imputation programs operated nearly identically to those used for the 1990 Census PES. (U.S. Census Bureau, December 2002.) The March 2001 A.C.E. used a different statistical model to account for missing data for match and residence status than the 1990 PES. The Census Bureau based the 1990 model on hierarchical logistic regression, while the 2000 model used the "Imputation Cell Estimator."[11] The input data and behavioral assumptions between the two models were similar but not identical.

The amount of missing data in the March 2001 A.C.E. was low. This low level minimizes the effect of the missing data assumptions on the final estimates. The Census Bureau found:

- March 2001 A.C.E. had high interview rates. Among occupied housing units, the Census Bureau had a 97.1 percent interview rate for Census Day and 98.8 percent for A.C.E. Interview Day. This compares to 98.4 percent (unweighted) in the 1990 PES. Because of the high response, most of the changes due to the noninterview adjustment factors applied were very small. This result helps keep down the variance of survey weights.

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[10] Missing match, residence, or enumeration status are referred to below as unresolved match, residence, or enumeration status. Sometimes we also refer to them as unresolved person status.

[11] The imputation cell estimator separated people with resolved and unresolved match or resident or correct enumeration status into groups called imputation cells based on operational and demographic characteristics. Within each imputation cell, the weighted proportion of matches or residents or correct enumerations among the cases with resolved status was calculated, and that value imputed for all unresolved people in the cell. (Cantwell et. al, 2001.)

- A low proportion, 2.2 percent, of people had unresolved residence. The missing data procedures assigned an average resident probability of 82.6 percent to people with unresolved resident status. As designed, this was lower than the average rate among people with resolved status (98.2 percent).

- Only 1.2 percent of the sample had unresolved match status, compared to 1.8 percent in the 1990 PES. The Census Bureau assigned an average match rate of 84.3 percent to people with unresolved match status, compared to 91.7 percent for those with resolved status. The low rate of unresolved match status implies only a small effect on the estimation.

- About 2.6 percent of the E sample had unresolved enumeration status compared to 2.3 percent in the 1990 PES. The average rate of correct enumeration for people with unresolved status was 76.2 percent compared to 95.9 percent for those with resolved status. (Cantwell et. al., 2001.)

- Similar to the 1990 PES, March 2001 A.C.E. had low rates of missing demographic data as shown in Table 4. There were few problems gathering answers to all questions about respondents in A.C.E. interviews for the P sample or from census forms for the E sample. This suggests that the post-stratification results accurately reflected respondents' true characteristics, and should help to reduce heterogeneity (i.e. the possibility for different people within post-strata to have different chances of being counted in the census and in the A.C.E.), since imputation determines the post-strata for only a small number of people. (Farber, 2001.)

Table 4: March 2001 A.C.E. and 1990 PES Missing Data Rates (weighted)

Missing Characteristic	March 2001 A.C.E.		1990 PES	
	P sample	E sample	P sample	E sample
Race	1.4	3.2	2.5	11.8
Hispanic Origin	2.3	3.4	Not Available	Not Available
Age	2.4	2.9	0.7	2.4
Sex	1.7	0.2	0.5	1.0
Tenure	1.9	3.6	2.3	2.5

While the missing data rates were low and the actual missing data treatments the Census Bureau used for the A.C.E. had small impacts on the estimates, the treatment of missing data can have a large effect on the A.C.E. estimates under certain assumptions. The Census Bureau considered, in various combinations, seven basic methods for addressing the noninterview and unresolved person status components of missing data in the March 2001 A.C.E. estimates. The Census Bureau used each resulting alternative model to compute new DSEs. The alternatives considered showed the choice of statistical model to account for missing data can have a substantial effect on the resulting estimates of coverage error, causing the DSEs to be over or understated. The

Census Bureau chose to represent the effects of these alternative models in the form of increased uncertainty in the March 2001 A.C.E. estimates.

The Census Bureau used the DSEs resulting from the alternative models to calculate a measure of variation similar to a sampling error. This evaluation found large non-sampling variability from the use of alternative missing data models. At the national level, the evaluation found the overall magnitude of the variation resulting from all combinations of the alternative statistical models used to account for missing data to be about 530,000. Arguments can be made that this measure understates the actual levels of variation due to missing data because it assumes each alternative was equally likely. (Spencer et. al, 2002.)

The Census 2000 unresolved enumeration status rates were slightly higher than those in 1990, but were not viewed as high enough to cause major concern. (Liu, Jones, and Feldpausch, 2001.) The alternative model analysis indicated that missing data had a larger effect than anticipated. This could have been due to changes in the methods for incorporating movers into the DSE, or to a more diverse set of alternative models than used in evaluation of the 1990 missing data procedures. (Mack et. al., 1991.)

For the 2010 Census, the Census Bureau should consider the following:

- If the Census Bureau expects low noninterview rates in 2010, then use the A.C.E. 2000 noninterview adjustment methodology. If not, then investigate and consider alternatives for noninterview adjustment. If the Census Bureau takes the suggestion in Section 3.2 to minimize proxy interviews, examine the relative trade off between dealing with proxies and with missing data.

- Write the A.C.E. characteristic imputation program from scratch rather then baseing it on a previously written program which was not well understood.

- Impute missing characteristics using the same methodology implemented for the census, especially for the E sample to increase consistency of demographic characteristics.

- Link the P- and E-sample files for each block cluster and use the available information for matched units for characteristic imputation, especially if the P-sample persons are missing the characteristics. When people match, consider using the census information to impute for those missing characteristics to reduce inconsistencies between the two samples.

- Design a flexible imputation plan so that prior to imputing, the Census Bureau can examine the data and determine an optimal imputation.

- For missing age, impute an age (a number), rather than an age category. Imputing a number rather than a category provides more flexibility for estimation and later evaluations.

- While for missing tenure, race, and Hispanic origin, the nearest-neighbor hot deck appears to work well, evaluate if alternatives could provide improvements.

- Model alternatives for sex imputation to see if improvements are possible.

- For the P sample, determine the probabilities of resident status and match status jointly. This helps account for the dependence between the two.

- When gathering information to be used to assign probabilities for unresolved person status, concentrate on information pertaining to the interview operations and field procedures (i.e. what went on), and less on demographic information (i.e. race, ethnicity, tenure, etc.). In Census 2000, the former information better classified cases for the purposes of assigning probabilities.

- Evaluate alternatives such as logistic regression and related software to assign probabilities for unresolved person status, but be careful not to over-model. (U.S. Census Bureau, December 2002.) There is the potential to improve probability estimates, but also the potential to increase variability.

- Use consistent coding and editing for race and other post-stratification variables in A.C.E. and census to increase consistency.

3.1.4 Dual System Estimation

Dual system estimation measured the degree of population net coverage error observed during the census enumeration. It accomplished this by comparing the census enumeration results to A.C.E. results to calculate dual system estimates separately by post-strata based on geography and demographic variables. Populations not included in dual system estimation were Group Quarters persons, Service-Based Enumeration persons, and persons in Remote Alaska.

The Census Bureau developed post-strata in reference to experience in all previous censuses, but especially the censuses of 1980 and 1990. In those censuses, since the net undercount was significantly larger than zero, they believed gross omissions was the dominant error, with gross erroneous inclusions being smaller. The Census Bureau also concluded that the determinants of net undercount would primarily follow socio-economic groupings.

The factors that caused erroneous inclusions probably drive the differential errors by demographic group and geographic area as much as those that caused omissions. The Census Bureau considered poststratifying separately for omissions (P sample) and erroneous enumerations (E sample). The Census Bureau rejected this approach because of the tight schedule. (Hogan, 2002.)

For 2010 post-stratification planning, the Census Bureau should consider these recommendations:

- Post-stratify the P and E samples separately to better account for both omissions and erroneous inclusions. (U.S. Census Bureau, December 2002.)

- Identify post-strata that better account for variability of socioeconomic groupings.

- Use generalized DSEs instead of postratification. This approach uses logistic regression to estimate probabilities of inclusion in the census and of correct enumerations. Post-stratification makes use of estimation cells which must be of sufficient size. Generalized DSEs are not limited by size constraints and thus offer greater opportunity to reduce biases.

For 2010 DSE implementation planning, the Census Bureau should consider the following recommendations:

- Consider using "Procedure B" to handle movers. In 2000 the Census Bureau used "Procedure C" with a few exceptions where we used "Procedure A". "Procedure C" and "Procedure A" match the nonmovers and outmovers at the Census Day address and within the search area. "Procedure C" and "Procedure A" rather than "Procedure B" were used in 2000 because it is easier to match within the search area. One problem with "Procedure C" and "Procedure A" was that interviews with whole households of outmovers were proxy interviews. "Procedure B" was used in 1990. For this procedure, the nonmovers were matched to the Census Day address and search area. The inmovers were matched to their Census Day address requiring collecting the Census Day address for the inmover, obtaining the census geography for the address, and matching to that address and surrounding blocks. This inmover matching was time consuming because the census questionnaires were printed from microfilm for clerical matching. The entire mover matching process could be improved in 2010 since names are captured for the entire country.

- Develop improved methods to detect erroneous enumerations and to incorporate duplicates into the coverage measurement survey estimates. (See Section 3.3, Erroneous Enumerations, Including Duplicates.)

- Use external data sources (e.g. administrative records, Demographic Analysis, American Community Survey) to improve coverage estimates.

- Include group quarters in future coverage measurement surveys to improve undercount estimates. (U.S. Census Bureau, December 2002.)

3.1.5 Synthetic Estimation

The last operation in the March 2001 A.C.E. estimation process, synthetic estimation, provided population estimates for small geographic areas such as blocks, tracts, counties, and congressional districts. The Census Bureau formed these small area estimates by applying coverage correction factors (i.e. the ratio of the DSE to the census count for each postratum) to the census counts at the different geographic levels. For example, the Census Bureau formed a block-level synthetic estimate by distributing a post-stratum's dual system estimate to blocks proportional to the size of the post-stratum's population within the block. For use in all census data products, the Census Bureau constructed rounded, adjusted synthetic estimates at the tabulation block level[12]. Data users then produce population estimates for any geographic area of interest by aggregating blocks. Populations not included in synthetic estimation were Group Quarters persons, Service-Based Enumeration persons, and persons in Remote Alaska.

For Census 2010, the Census Bureau may want to consider a modeling approach to DSEs. In this case, the Census Bureau would not need a separate synthetic estimation procedure.
(U.S. Census Bureau, December 2002.)

3.1.6 Variance Estimation

The Census Bureau expected the sampling variances and coefficients of variation (CV) to be lower for the March 2001 A.C.E. compared to the 1990 PES because:

- The housing unit sample size for the A.C.E. was almost double that of the PES (approximately 300,000 versus approximately 165,000).
- Better measures of population size were available during sample selection of clusters.
- Sampling weights were less variable.

As expected, the improvements led to much smaller sampling variances. The actual reduction was larger than the 25 percent expected reduction due to the increase in sample size. This is seen from Table 5. Also:

- The CVs declined for forty-seven states, with an average reduction of 36.8 percent.
- At the Congressional District level, the median CV decreased by about 40 percent, from 0.499 percent to 0.297 percent.
- The median CV decreased by roughly 50 percent, from 0.629 percent to 0.314 percent, for places with a census population greater than 100,000.

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[12] Data is collected for blocks usually defined by physical features. After the Census is completed, blocks are split by other boundaries, such as political boundaries, to create new blocks. Data is tabulated based on the new block definitions.

- The median CV decreased by about 40 percent, from 0.510 percent to 0.310 percent, for counties with a census population greater than 100,000. (Starsinic et. al, 2001.)

Table 5: Distribution of CVs[13] for Population Estimates by Geographical Area for March 2001 A.C.E. and 1990 PES

Area	Source	Number	Mean Size	Mean CV	Margin of Error*	Distribution of CVs				
						Minimum	Q1	Median	Q3	Maximum
State **	A.C.E.	51	5,582,035	0.310%	28,506	0.159%	0.220%	0.240%	0.378%	0.804%
	PES	51	4,955,153	0.449%	36,623	0.322%	0.369%	0.406%	0.496%	0.933%
Congressional Districts ***	A.C.E.	435	653,103	0.330%	3,546	0.156%	0.250%	0.297%	0.375%	0.948%
	PES	435	579,567	0.557%	5,309	0.299%	0.420%	0.499%	0.628%	2.007%
Places > 100,000 ****	A.C.E.	245	315,037	0.343%	1,776	0.213%	0.283%	0.314%	0.361%	1.435%
	PES	195	335,637	0.673%	3,718	0.363%	0.536%	0.629%	0.747%	1.702%
Counties > 100,000 ****	A.C.E.	524	409,345	0.368%	2,481	0.201%	0.274%	0.310%	0.405%	1.498%
	PES	458	400,593	0.534%	3,519	0.285%	0.432%	0.510%	0.591%	1.483%

* - Margin of Error is calculated as 1.645 × standard error of the population estimate.
** - "State" includes all 50 states and the District of Columbia.
***- 103rd Congressional Districts for the PES; 106th Congressional Districts for the A.C.E.. Does not include the District of Columbia or Puerto Rico.
****-Counties and places with census counts of more than 100,000 in the respective censuses, 2000 for A.C.E. and 1990 for PES.

The Census Bureau used replication methods to estimate the variance due to A.C.E. and PES sampling and estimation. Unlike the PES, the March 2001 A.C.E. replicate variances of the census estimates had three components:

- Variance due to the multi-phase sampling of block clusters for the A.C.E.
- Variance due to sampling for the Targeted Extended Search.
- Variance from estimating the missing data in A.C.E.

The variance computation accounted for some of the components of variance due to missing data, but it is unknown whether it largely accounted for the variance due to missing data since the computation did not include the variance component due to the selection of statistical model to account for missing data. The alternative models evaluation conducted by Keathley, Kearney, and Bell (2001) indicated this component may be large.

[13] Synthetic error is not incorporated into the A.C.E. variance estimates. The assumption is that the coverage rate is uniform over all areas within post-strata. Synthetic error is introduced to the extent the areas deviate from this assumption. The accuracy of this methodology may decrease in areas where localized effects not reflected in the post-stratification affect the true sampling variance. The discrepancy becomes larger as the population of an area decreases. Thus, caution should be used in comparisons between areas of different sizes. (Starsinic et. al., 2001.)

The Census Bureau should consider whether the use of complex variance methods would be more beneficial in production or in an evaluation of the production variances. They should also consider developing confidence measures for A.C.E. that reflect synthetic error and other nonsampling error as well as sampling error.

3.2 A.C.E. Person Interviewing

Byrne, Imel, Ramos, and Stallone (2001) examined the A.C.E. person interview operation. The interviewing operation had two phases: telephone and personal visit. The personal visit also used a NonResponse Conversion Operation (NRCO) to try converting the noninterviews by using the best interviewers.

Dates of the operation:

- Telephone Phase April 24, 2000-June 13, 2000
- Personal Visit Phase June 19, 2000-September 11, 2000
- Nonresponse Conversion July 27, 2000-September 11, 2000

The A.C.E. planned all interview activities to end on September 1, 2000. However, one local census office, Hialeah, Florida required more time to complete the census data collection operations. This resulted in a delay for the subsequent A.C.E. person interviewing in Hialeah until August 18, 2000-September 11, 2000. All other offices finished interviewing on schedule, September 1, 2000.

The 2000 A.C.E. did not use a paper form as used in the 1990 PES. The Census Bureau used computer assisted personal interviewing (CAPI) software.

Byrne, Imel, Ramos, and Stallone (2001) provide results of the interviewing operation:

- Almost all (99.9 percent) interviews resulted in a satisfactory outcome. The Census Bureau classified only 0.12 percent of all interviews as either refusal, language barrier, or no knowledgeable respondent noninterviews.

- The Census Bureau completed 29 percent of the total A.C.E. workload during the telephone phase. As a result, the interview phase ended with much less time transpiring between Census Day and the day of the interview, potentially reducing recall bias. The Census Bureau classified over 99 percent of the telephone cases as complete or partial interviews conducted with a household member.

- The Census Bureau classified 84 percent of the personal visit interviews as either complete or partial interviews and found 14 percent to be vacant on Interview Day. This accounts for

98 percent of the personal visit workload. Of the remaining 2 percent, 1.9 percent were nonexistent units on Interview Day and 0.2 percent were noninterviews.

- Interviewers converted 70.8 percent of the cases sent for NRCO from the telephone and personal visit phases to complete interviews and 14.1 percent to partial interviews. Of the remaining cases, 11.4 percent converted to vacant units and 1.5 percent to nonexistent units. Only 2.2 percent of the NRCO cases finished as refusals.

- Automating the interviewing enhanced the quality of data captured in the interviews, expedited the turnaround time for reassigning interviews and providing feedback to the interviewers, and instilled the interviewers with a sense of professionalism and purpose.

- The Quality Assurance (QA) operation helped keep the rate of error low and indicated a high level of data quality.

The QA of person interviewing helped ensure correct results from the telephone and personal visit phases of the operation. The QA sample was from two sources: a five percent random sample of the total caseload and targeted cases selected by the QA supervisors because they were likely to contain inaccurate information or insufficient data quality. Only 190 cases failed the QA. For all such cases, the Census Bureau obtained and used a replacement interview in the survey. The Census Bureau effectively weeded out several interviewers whose work had egregious errors. The Census Bureau accomplished more by targeting for problematic cases than through randomly sampling cases. The low failure rate in the random sample meant the errors in person interviewing were under control.

Highlights of the QA results:

- The overall failure rate for the targeted cases (0.85 percent) was dramatically different from the randomly selected cases (0.13 percent). This pattern held for both telephone and personal visit interviews, suggesting targeting was effective in identifying cases likely to fail the quality assurance.

- Because of the data edits and automated skip patterns, as well as the quick turnaround time for cases to get assigned and completed in QA, automating both the original person interview and the QA reinterview enhanced the overall quality and efficiency of the person interview operation.

Wolfgang, Byrne, and Spratt (2003) examined the characteristics of people and households by respondent type (i.e., interview with a household or nonhousehold member). Among the original A.C.E. person interviews, the age group below 18 had the lowest percent interview with a nonhousehold member or proxy. The age group between 18 and 29 had the highest percent proxy in the person interview. The owners had a lower percent proxy than the non-owners. The race category containing Non-Hispanic Black had the highest percent proxy and all other race

categories were not significantly different from each other. The people in multi-unit structures had a higher percent proxy than people in single unit structures. Single person households had a higher percent proxy interview than larger households.

The people who did not match to the census had a larger percent proxy than people who matched. The Census Bureau sent P-sample people to followup because we were not absolutely certain about the information provided in the original interview, such as not matched people from proxy interviews, from conflicting households, and from households where some people matched. Among the followup interviews for the A.C.E., 25.6 percent were proxy interviews in the A.C.E. original interview and the Census Bureau got a household member as a respondent in followup for only 35.3 percent of the original proxy interviews. For followup interviews, the percent proxy for the P-sample people removed because they were not residents of the household or were fictitious was lower (15.4 percent) than for the P-sample people who were not removed (33.5 percent).

Wolfgang et. al. examined characteristics of the matched people looking at the respondent type. When the 2000 A.C.E. responses for various characteristics did not agree with census responses, they found a higher percentage of proxy responses than when the responses agreed.

These data raise issues about the data quality provided by non-household members. The percent of proxy respondents (5.5 percent) in the 2000 A.C.E. interview raises questions about the effect of proxy data on the undercount estimates. The 2010 coverage measurement program should minimize proxy interviews and only accept interviews from knowledgeable respondents.

3.3 Error Sources

Three studies produced substantial information on error components associated with the P and E samples: the Matching Error Study (MES), the Evaluation Followup (EFU), and the Person Duplication Studies.

- Matching Error Study

The Matching Error Study (Bean, 2001; Bean, 2002) provided the P-sample matching error rate and the E-sample processing error rate. Expert matchers clerically rematched all of the people in a one-fifth subsample of the A.C.E. sample clusters to determine the match code. They then compared these codes to the match codes assigned to produce the March 2001 A.C.E. estimates.

- Evaluation Followup

The EFU (Krejsa and Raglin, Report 3, 2001; Krejsa, 2001; Raglin and Krejsa, Report 16, 2001; Adams and Krejsa, 2001; Krejsa, 2003) consisted of a reinterview of a subsample of households in the one-fifth subsample of A.C.E. clusters used in the Matching Error Study. The Census Bureau used the EFU interview results to measure the E-sample classification

accuracy of correct and erroneous census enumerations. They also used the results to measure the P-sample data accuracy regarding mover status and Census Day residence.

• Person Duplication Studies

The Person Duplication Studies (Feldpausch, Report 6, 2001; Fay, 2002; Thompson, Waite, and Fay, 2001; Mule, Report 20, 2001) took advantage that Census 2000 recorded name information in the data capture system. For the first time, this new information permitted the Census Bureau to conduct nationwide computer matching to measure census duplication. These studies also examined how well the A.C.E. accounted for these duplicates. While the A.C.E. matched respondents in the same block and surrounding blocks, this new tool permitted the Census Bureau to search for duplicates throughout the country. Because the Census Bureau lacked resources to conduct both a computer and clerical match to the entire country, the Person Duplication Studies involved only computer matching. This resulted in an understatement of the actual duplication level. These studies compared the results of the EFU with the Person Duplication Studies to determine if the EFU correctly measured duplications.

Some error components produced from the Matching Error Study, Evaluation Followup, and Person Duplication Studies suggest the March 2001 A.C.E. overestimated the net undercount while other studies suggest the net undercount was underestimated. The results from these and other studies are discussed below as we examine:

- Erroneous enumerations
- Census omissions
- Balancing error
- Correlation bias
- Conditioning
- Reinstated late additions
- Census 2000 imputations

3.3.1 Erroneous Enumerations, Including Duplicates

Evaluations indicated that the March 2001 A.C.E. did not measure a substantial portion of the Census 2000 erroneous enumerations. The measurement of erroneous enumerations is critical to both the national net undercount and to sub-national estimates. This error resulted in the March 2001 A.C.E. overstating the net Census 2000 undercount by at least three million people, with a range of three to four million. (ESCAP II, 2001.)

The EFU and Person Duplication Studies described above provided substantial information regarding the measurement of erroneous enumerations. The initial EFU results gave evidence of a significant understatement in the March 2001 A.C.E. measurement of erroneous enumerations. Because of the size of the understatement, the EFU was extensively reviewed. The revised EFU

also indicated a problem with understating the erroneous enumerations. The revised EFU had a high level of unresolved[14] or conflicting cases[15]. The Person Duplication Studies found a significant number of duplicate enumerations not measured by the March 2001 A.C.E. and that the EFU did not pick up significant portions of this error. The Person Duplication Studies resolved a portion of the cases left unresolved or conflicting by the EFU Review.

Three and a half percent of the EFU sample changed enumeration status as recorded by the March 2001 A.C.E. The EFU re-coded about 2,800,000 estimated (SE 223,000) "correct enumerations" as "erroneous enumerations" and re-coded about 900,000 estimated (SE 99,000) "erroneous enumerations," as "correct enumerations". (Krejsa and Raglin, Report 3, 2001.) The EFU found an estimated net difference of 1,900,000. Also, about 4,500,000 estimated (SE 353,000) cases in the EFU could not be resolved. This study showed the March 2001 A.C.E. overstated the net undercount by a minimum of about two million people. (ESCAP II, 2001.) For comparison, the 1990 evaluation study (West, 1991) of erroneous enumerations found the 1990 PES understated the net undercount by about 360,000 estimated persons. West also found about 1,273,000 estimated E-sample people could not be matched or were unresolved. (In 1990, the EFU was a reinterview using the 1990 Person Followup (PFU) form. In 2000, the EFU was designed to differ from the 2000 PFU form, including more residency probes.)

Because of the EFU's implications for the March 2001 A.C.E. estimates, further EFU analysis was conducted. Better trained matching analysts from the National Processing Center (NPC) reviewed a subsample of the EFU and production cases. This review of the original EFU confirmed the errors in the March 2001 A.C.E.'s identification of erroneous enumerations. About 1,800,000 estimated (SE 189,000) enumerations coded as correct in production were then coded erroneous in the evaluation, while about 361,000 estimated (SE 46,000) enumerations coded as erroneous in production were then coded as correct in the review. (Adams and Krejsa, 2001.) Consequently, the net difference in the "correct enumeration" to "erroneous enumeration" and "erroneous enumeration" to "correct enumeration" cells was estimated to be 1,450,000, rather than the initial 1,900,000. However, the review identified over 15 million estimated cases which could not be resolved or had conflicting A.C.E. and EFU information. (Adams and Krejsa, 2001.) The coding of erroneous enumerations was conservative because the purpose of the review was to determine if the original coding designated too many erroneous enumerations. This created a large number of conflicting cases. Depending on assumptions regarding the enumeration status of these conflicting cases, the estimated overstatement of the net undercount could range from about 1.45 million to 5.9 million people. (ESCAP II, 2001.)

The Person Duplication Studies found a significant number of duplicate enumerations were incorrectly measured in the March 2001 A.C.E. or in the EFU. Furthermore, upon combining the Person Duplication Studies results with the review of original EFU results, the Census Bureau

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[14] Unresolved people are those for whom the Census Bureau did not have enough information to accurately code whether they should be counted as erroneous or correct enumerations.

[15] Conflicting people are these for whom the Census Bureau obtained different residency information in PFU and EFU and the Census Bureau could not determine which was correct.

could explain some of the unresolved and conflicting cases. Based on this work, they developed more refined ranges for the March 2001 A.C.E. overstatement level. Direct estimates produced from the Person Duplication Studies indicated the March 2001 A.C.E. error not measured was about three million persons. In addition, the Census Bureau expected further refinements (Fay, 2002) to the treatment of the unresolved and conflicting cases would lead to about an additional 800,000 errors. Thus, they reduced the estimated net undercount overstatement range to three to four million persons. (ESCAP II, 2001.)

Martin, Fay, and Krejsa (2002a; 2002b) conducted a preliminary evaluation of the A.C.E. Person Followup and EFU questionnaires to understand their success in identifying erroneous enumerations. They examined the consistency of residency reporting in the two surveys, and used duplication rates to assess the validity of the classifications produced by the two questionnaires. They examined responses to questionnaire items, and did not incorporate information from clerical coding of interviewer's notes which formed the basis of official estimates of Census 2000 coverage. The A.C.E. Person Followup questionnaire attempted to determine Census Day residence with only a few global questions; the EFU questionnaire asked a larger number of more detailed questions. Martin et. al.'s analysis indicated high levels of inconsistent reporting of moves in and out of households, second residences, and stays in group quarters. They found that identification of enumeration errors appears to have been greatly enhanced by taking into account information from both surveys, because each questionnaire added information about errors that were not identified by the other. Neither questionnaire could be said to represent a "gold standard" for reporting accuracy. (Martin, 2001.) They also found that the EFU identified small but significant numbers of erroneous enumerations among the matched cases, and these cases had high rates of duplication.

Martin, Fay, and Krejsa (2002a; 2002b) and Martin (2001) identified the following as research related to erroneous enumerations identification needed for 2010:

- Review residence rules and critical definitions to create a simpler classification scheme that relies on clearer definitions that can be understood by interviewers and respondents in the field.

- Devote resources to long term coverage measurement instrument improvements. Research and instrument development and testing are needed to address conceptual, recall, and comprehension issues affecting group quarters residence and multiple residence reporting. A further goal for research and development should be to reduce reliance on expensive, time consuming and labor-intensive clerical coding operations. Accurate classifications should be produced by the standardized questions in the instrument, reducing the need for intervention and interpretation by analysts and clerks.

- Develop a coverage measurement design that better integrates instruments for the A.C.E., followup surveys, and evaluations. Explore how to improve coverage measurement by maximizing the potential each data collection instrument offers. For example, it would be

desirable for the PFU instrument to do more probing as was done by EFU. The EFU and PFU instruments might also be designed to identify census or A.C.E. omissions. The Census instruments might collect additional information to facilitate residence determinations.

The EFU provided information regarding whether the March 2001 A.C.E. accurately identified Census 2000 discrepant enumerations.[16] This study showed no problem with the identification of discrepant enumerations. (Krejsa, 2001.)

Mule (Report 20, 2001) and Jones (Report 0.16, 2003) found higher duplication rates for certain subgroups and areas. Both found higher duplication rates among Non-Hispanic Blacks and Hispanics compared to other race/ethnicity subgroups and among 18 to 29 year old males compared to other age/sex subgroups. Additionally, Jones found duplication more prevalent in small multiunit housing structures and mobile homes compared to other housing type subgroups, in the New York and Boston regional offices compared to other regional offices, among renters compared to owners, and among persons in duplicate housing units or in housing units added to the census inventory after 1990 compared to persons included in other ways. These findings suggest that it may be beneficial to target these subgroups and areas in conducting person duplicate searches.

Finally, Feldpausch (2001) examined the relationship between the E-sample people identified as duplicates outside the search area and their corresponding March 2001 A.C.E. enumeration status. In past censuses, the Census Bureau had no way to evaluate the coding of people duplicated outside the post-enumeration survey's search area. For Census 2000, analyses preceding the Person Duplication Studies searched for duplicates throughout the country. Mule (Report 20, 2001) conducted computer matching to determine the extent of duplicate enumerations not found in the March 2001 A.C.E. This allowed him to evaluate the March 2001 A.C.E. coding of people duplicated outside the search area.

A person enumerated twice by the census was duplicated. The record of a person enumerated in the correct place should have been coded as a correct enumeration. The record of a person enumerated in an incorrect place according to census residence rules should have been coded as an erroneous enumeration.

Feldpausch found a lower than expected percentage erroneous enumeration for E-sample people duplicated to people in group quarters where the residents were not allowed to claim usual home elsewhere (45.5 percent for college dorms and 16.5 percent for other group quarters). This rate

[16] Discrepant enumerations include falsification (the amount is uncertain), but do not include honest mistakes made by the interviewers or respondents. A person is classified as discrepant during the matching operation if three knowledgeable respondents indicate not knowing him or her in either the EFU or production interview.

should have been closer to one hundred percent because for the majority of these people their usual residence was probably the group quarters.

For those E-sample people duplicated to people in group quarters allowed to claim usual home elsewhere, Feldpausch found a higher than expected percentage erroneous enumeration (12.5 percent). The erroneous enumeration rate for these people should have been close to zero because the housing unit, not the group quarters, was probably their usual residence.

The percentage erroneous enumeration for E-sample people duplicated to people in housing units outside the A.C.E. search area (14.2 percent) was lower than the approximate 50 percent one might have expected. One might expect 50 percent because half of the time the wrong housing unit should be in sample, resulting in coding the residents as erroneous.

Some possible explanations of these findings are:

- The instructions indicating who to include on the census questionnaire may not have been completely understood or were ignored by the respondent. Examples of living situations causing problems include college students, people in local jails, and people in nursing homes.

- The respondent may not have known a household member was enumerated elsewhere.

- Some group quarters' enumerations may have used administrative records not reflecting residents as of April 1, 2000.

- Residence in some group quarters is temporary, such as local jails. Some people counted in these may be usual residents of the sample housing unit.

- The computer matching of duplicates outside the search area might be incorrect. The Census Bureau does not think this was likely, because the Census Bureau only looked at those cases that had a high probability of being linked correctly.

- The March 2001 A.C.E. failed to completely identify erroneous enumerations due to other residence. The percent other residence was 1.4 in the March 2001 A.C.E. and 2.3 in the 1990 PES (these percentages reflect the redistribution of people with unresolved status). The results of the Evaluation Followup also measured this phenomenon.

Evidence suggests the March 2001 A.C.E. did not code some people as erroneous enumerations who should have been because they lived in other residences. Some people were identified as erroneous enumerations because they should have been counted at another address. In many of these cases they were also counted where they should have been counted, making them duplicates.

These studies show that the Census Bureau needs to conduct further research to better identify erroneous enumerations, including duplicates in the 2010 census. This research should investigate changes in residence rules, data collection procedures, coding procedures and instruments and improved estimation approaches. Further work by Martin, Fay, and Krejsa (2002a; 2002b) suggests that the Census Bureau consider sending a subsample of matched cases to followup during production because there may be undetected erroneous enumerations among them.

Additional information about erroneous enumerations for Census 2000 may be found in Adams and Liu (2001); Bean (2001); Bean (2002); Feldpausch (2002); Liu, Jones, and Feldpausch (2001); Liu, Byrne, and Imel (2001); and Raglin and Krejsa (Report 16, 2001).

3.3.2 Census Omissions

The Census Bureau used the P sample to measure census omissions. Therefore, matching of P sample to the census, the classification of P-sample mover status and Census Day residence, and the determination of P-sample discrepant enumerations were critical aspects of the P-sample processing. The MES produced information about matching accuracy. The EFU provided information about the accuracy of the classification of movers and Census Day residence and the lack of discrepant enumerations.

In the A.C.E. clerical matching, clerks examined computerized P-sample responses and census responses. They also had access to the scanned images of the original questionnaires. Because of automation of the matching operation, all matching could be done at one location, instead of seven as in 1990. (National Research Council, 2001.)

The Census Bureau conducted a Matching Error Study for the Census 2000 Dress Rehearsal Integrated Coverage Measurement (ICM) and for the 1990 PES. The MES for the Census 2000 Dress Rehearsal was unable to measure significant matching error because of a 100 percent QA during the Census 2000 Dress Rehearsal ICM[17]. The match code discrepancy rates (which represent the size difference between the person-level ICM and MES matching) for the P sample were less than one percent in all sites.

[17] For the Dress Rehearsal ICM, the Census Bureau planned to conduct QA on only a portion of the work, but logistical concerns necessitated a 100 percent QA. For the 2000 A.C.E., QA was done on a sample basis once the matcher reached a specified level of proficiency (periodically, the matching software reevaluated the decision to sample). The sample QA involved a dependent rematch on 1/6 of the clerks' (the lowest level of matchers) and 1/10 of the technicians' (the middle level of matchers) work. In addition, cases meeting special "must do" criteria were reviewed. (Byrne, 2001.)

The 1990 MES found the PES generally tended to overestimate the P-sample nonmatches, especially when matching central city, minority persons. By evaluation poststratum (based on region, urbanicity, and minority status) the biases due to matching error ranged from approximately 0.7 percent to 1.3 percent of the population sizes. Of particular concern, the PES overestimated nonmatches for Blacks by about 4.5 percent which equated to an approximately 0.7 percent positive bias in the total Black population. (Davis and Biemer, #H-2, 1991.)

Reductions in matching error from 1990 to 2000 provide evidence that changes made from 1990 improved the quality of the A.C.E. matching process. Even with these improvements, matching error from the P and E samples combined inflated the national dual system estimate by 483,938 with a standard error of 92,877 and therefore overstated the undercount estimate (holding all other errors constant). (Bean, 2001; Bean 2002.) To further reduce matching error in the future, planners should continue efforts to improve the matching process. Improvements to the matching process may be made by:

- simplifying the targeted extended search (TES) matching procedures and improving the quality control for the TES clusters;
- identifying ways to further ensure that matchers update cases with insufficient information for matching; and
- clearly defining rules for coding cases as discrepant or unresolved. (Bean, 2002.)

The EFU showed that misclassification of movers in the March 2001 A.C.E. may have resulted in an estimated understatement of about 450,000 in the net undercount. (Raglin and Krejsa, Report 16, 2001.) This final effect results from significant changes in mover status. These changes involved a large number of movers becoming nonmovers and vice versa. The EFU estimated that about 4.5 million people classified as "movers" in production became EFU "nonmovers," and about 2.4 million people classified as "nonmovers" in production became EFU "movers." At the national level there is a small estimated net effect of about 65,000 on the accuracy of the measurement of census omissions.

The Census Bureau was concerned about the EFU measurement of movers who became nonmovers, specifically about whether the EFU measured too few movers, due to its questionnaire design. The EFU required less detailed information for classifying a person a nonmover than for classifying a person a mover. An examination of the bias caused by mover status changes indicated the effect of mover-to-nonmover changes was greater in absolute value than the effect of nonmover-to-mover changes. Even though the net effects of these errors cancel at the national level, assessment of the subnational effects requires further research.

Martin, Fay, and Krejsa (2002a; 2002b) examined the EFU questionnaire in regard to mover identification. Results indicated high levels of unreliability in measurement of movers in and out of households. Research and instrument development testing are needed to address issues affecting the reporting of moves.

The EFU also demonstrated that A.C.E. did not have a large problem with discrepant enumerations. The EFU identified a weighted net 326,855 P-sample residents who should have been removed because they were discrepant. Up to 23,879 weighted people were excluded as P-sample residents, but identified as potentially discrepant by the EFU. (Krejsa, 2003.)

The MES and EFU studies suggest the Census Bureau should continue efforts to improve the matching process and conduct research to improve the reporting of movers for 2010.

Additional information about census omissions and movers for Census 2000 may be found in Liu, Jones, and Feldpausch (2001); Liu, Byrne, and Imel (2001); and Wolfgang, Adams, Davis, Liu, and Stallone (2001).

3.3.3 Balancing Error

Balancing error may occur if the search areas for matches to the surrounding blocks do not equal search areas for correct enumerations in the surrounding blocks, the Census Bureau coded the data inconsistently, or the Census Bureau introduced P-sample geocoding error. Since the A.C.E. used a random sample independent from the census, the Census Bureau expected census housing units should be erroneously included within A.C.E. sample clusters as often as census housing units should be erroneously excluded from A.C.E. sample clusters. After adjusting for the P-sample coverage, if the problems above occurred, the weighted number of matches to surrounding blocks may not have equaled the weighted number of correct enumerations, creating balancing error. (Adams and Liu, 2001.)

The A.C.E. carried out matching in a defined search area consisting of the A.C.E. sample blocks (clusters) and a targeted area of blocks surrounding or bordering the A.C.E. blocks (i.e. Targeted Extended Search Area). The March 2001 A.C.E. found three million more matches in surrounding blocks than correct enumerations, indicating balancing error as a potential problem. This could have affected the accuracy of the estimates. The Census Bureau identified various scenarios that could explain the differences. Also, the Census Bureau conducted evaluations to investigate the source of this difference, identify the scale of any error, and assess whether its magnitude could significantly affect the accuracy of adjusted data.

The evaluation attributed most of the three million difference to the A.C.E. listing housing units in the blocks surrounding the sample blocks. This had little, if any, effect on the DSE. However, the evaluations detected about 246,000 additional A.C.E. people (SE 82,000) located out of the surrounding blocks due to P- sample geocoding errors. (Adams and Liu, 2001.) The evaluations also estimated an additional 195,000 people (SE 56,000) incorrectly identified as having been correctly enumerated, although found outside of the search area. These errors resulted in an overstatement of the net undercount by about 450,000 persons. The EFU and MES results included portions of these errors. While additional work is required to resolve the potential effects of balancing error, the Census Bureau believes that most of the concerns regarding balancing error have been addressed.

The relationships between variables used in defining post-strata for dual system estimation and variables relevant to sampling of Targeted Extended Search cases revealed no concern with geocoding error or insight for improving geocoding error. (Wolfgang, Stallone, and Adams, 2002.)

3.3.4 Correlation Bias

Correlation bias refers to the tendency for census enumerated people to more likely be included in the A.C.E. than people missed by the census. It can result from causal dependence, which occurs when the act of being included in the census makes some people more likely or less likely to be included in the A.C.E. Correlation bias can also result from heterogeneity bias, which arises when different people within poststrata have different chances of being included in the census and also different chances of being included in the A.C.E. To cause this type of bias, these chances of inclusion must be correlated, as when those likely to be missed by the census are also more likely to be missed by the A.C.E. This type of heterogeneity would result in a downward bias in the DSEs. In March 2001, the Census Bureau assessed possible correlation bias in the A.C.E. estimates by comparing the A.C.E. and DA results
(Bell, B-12*, 2001). These correlation bias estimates used DA estimates as of February 26, 2001. The correlation bias estimates were recomputed in October 2001 to use the Revised DA estimates (Bell, Report 10, 2001).

Although there is evidence of and reason to expect some correlation bias in dual system estimates, the Census Bureau did not correct for it in DSEs produced up to March 2001. For the 1990 PES there was concern about the newness of the methodology for estimating correlation bias and about the time required to fit a correlation bias adjustment into the production schedule. There was also concern that alternative models for correlation bias could be used that provided the same fit to the data but yielded different subnational estimates. This latter concern was also present for the 2000 A.C.E., leading to the decision made in the planning stages not to adjust those estimates for correlation bias. Another part of the thinking behind this decision was the that, in the presence of census undercounts, DSEs without adjustment for correlation bias are conservative in that they move the estimates in the right direction, though perhaps not fully correcting for net undercoverage. This thinking tied in with concerns that adjustment for correlation bias could overshoot the truth, at least for some population groups, a justifiable concern if other biases in the DSEs are positive tending to make them overestimates (as was the case with the March 2001 A.C.E. estimates). A.C.E. Revision II faced a different situation, however, because (i) it corrected its DSEs for other biases (such as the underestimation of erroneous enumerations due to duplication), and (ii) there was evidence of some net overcounts and some smaller undercounts for various groups in the 2000 census. In this situation DSEs without adjustment for correlation bias were not seen as conservative, as they could estimate overcounts for groups that were truly undercounted, and thus move estimates further from, not closer to, the truth. Because of this, the treatment of correlation bias was reconsidered and A.C.E. Revision II did correct its estimates for correlation bias. For the 2010 census, the Census Bureau should re-evaluate whether to adjust for correlation bias.

3.3.5 Conditioning

Conditioning, or contamination bias, refers to the situation where the A.C.E. influenced the census. As in the 1990 Census, contamination bias was not a problem in Census 2000, as research did not identify any strong evidence of its presence. Therefore, procedures to avoid contamination bias appear to work. (Bench, 2001; Bench 2002.)

3.3.6 Late Additions

The Census Bureau made substantially more late additions than in the 1990 census. Late additions refer to persons included in the final census count who were excluded from A.C.E. matching and dual system estimation because of their late inclusion. For Census 2000, the late additions consisted exclusively of housing units temporarily removed from the census because the Census Bureau suspected they duplicated other housing units, but which they later reinstated into the final census after further research. The housing units were reinstated after the A.C.E. matching process started (i.e. the matching process did not influence the decision of what to reinstate). If the reinstated people were a small percentage of the census, or if their A.C.E. coverage rate was similar to the A.C.E. coverage rate for census people included in the A.C.E., then there would be minimal effect on the DSEs. (Hogan, Q-43, 2001.) The Census Bureau validated this assumption by clerically matching the reinstated people collected in A.C.E. and census in evaluation clusters (a 1/5th sample of A.C.E. clusters), attempting to mimic as best as possible what would have happened had they been among the census people in the production matching operations. (Raglin, 2001.)

Based on this additional work, the Census Bureau concluded that excluding reinstated census people from the A.C.E. had little effect on the DSE. The March 2001 A.C.E. coverage rate may have been overestimated by 0.034 to 0.082 percentage points. (Raglin, 2001.)

3.3.7 Census Imputations

Census 2000 experienced a higher rate of whole person imputations than the 1990 census. The Census Bureau excluded whole person imputations from A.C.E. matching activities, but reflected them in the census coverage error as measured by the A.C.E. The Census Bureau examined whether Census 2000 design features explained the whole person imputations (and thus should have no discernible impact on the A.C.E.), concluding that the kind, level, and pattern of whole person imputations in Census 2000 raised no issues relative to the accuracy of the March 2001 A.C.E. adjustment. (ESCAP II, 2001.)

Approximately 5.77 million persons had all their characteristics (short form data items[18]) imputed in Census 2000, compared to 1.97 million persons in the 1990 census. The Census Bureau added approximately 1.2 million of these persons to the census count through a count imputation process. The Census Bureau counted the remaining 4.6 million persons directly through the census enumeration process, but imputed all their person characteristics because information about them was substantially missing from the census records. (Nash, 2001.) Research into the sources of the whole person imputations identified changes in the way data were collected for large households as contributing to the level of housing units requiring imputation. Furthermore, the count imputation rate was comparable to the rate experienced in the 1970 and 1980 censuses. (ESCAP II, 2001.)

The Census Bureau also examined characteristics of the imputed persons. It found similar distributions between the age, race and sex characteristics of the population requiring some form of imputation and the data-defined[19] population with the exception of the age category under 18. The high proportion of younger people in the within household category caused the relatively higher percent of the population under 18 in the imputed population. This reflected the fact that large households (greater than six) likely have children not able to be accommodated by the six-person mail-return form, which would require imputation if their characteristics were not collected in the coverage edit followup. (Wetrogan and Cresce, 2001.)

For the 2010 census, the Census Bureau should identify ways to reduce whole person imputations.

4. A.C.E.: Housing Coverage

The Census Bureau conducted studies to examine housing unit coverage. These studies looked at the net undercount as well as the P-sample nonmatches and E-sample erroneous enumerations for housing units. They examined types of erroneous enumerations, including the housing unit duplication for Census 2000. Another study examined conflicting households, which are matched housing units with different people in the P sample and the E sample.

The census flagged approximately 2.4 million housing units as potential duplicates, which A.C.E. processing excluded. (Nash, Memorandum 78, 2000.) The Census Bureau reinstated one million of these housing units into the census. (Nash, Memorandum 82, 2000.) None of the studies in this section included these reinstated housing units.

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[18] Short form data items are the census data items that were to be collected for all persons and households.

[19] The data-defined population includes census person records with sufficient data to be accepted for further processing. Data defined records for Census 2000 must have at least two completed items. One item may be name, defined as at least three characters in the name field. Records that are not data defined are whole person imputations.

The studies examined the field operations and instruments used during the housing unit phase of the A.C.E. and made recommendations about their use in coverage measurement for 2010.

4.1 Housing Unit Coverage Study

Barrett, Beaghen, Smith, and Burcham (2003) examined the results of the Housing Unit Coverage Study (HUCS). The HUCS measured the Census 2000 housing unit coverage using data from the A.C.E. Using DSE, it estimated the net coverage of housing units enumerated in Census 2000. The HUCS estimated nonmatches from the P sample of housing units and erroneous enumerations from the E sample of housing units. Together they estimate the net undercount of housing units.

Coverage of housing units enumerated in Census 2000 was comparable to the housing unit coverage in 1990. Table 6 shows:

- A net undercount of housing units of 0.61 percent in Census 2000 and 0.96 percent in 1990. The net undercounts were both significantly different from zero, but not significantly different from each other.

- For occupied housing units, there was no observable significant difference between the 2000 and 1990 coverage, with a net undercount of 0.33 percent in 2000 and 0.53 percent in 1990.

- A net undercount for vacants at 3.37 percent in 2000 was not significantly different from the 4.71 percent net undercount in 1990.

Table 6: Comparison of 1990 and 2000 Percent Net Undercount of Housing Units (Standard error)

Status	2000 HUCS	1990 HUCS
National	0.61 (0.16)	0.96 (0.24)
Occupied	0.33 (0.13)	0.53 (0.21)
Vacant	3.37 (0.98)	4.71 (1.26)

Barrett, Beaghen, Smith, and Burcham (2003) also found the coverage for occupied housing units consistent with 1990 for various research categories such as tenure and type of enumeration area.

- In 2000, the undercount for vacant housing units (3.37 percent) was significantly greater than for occupied units (0.33 percent). In 1990, the undercounted for vacant housing units (4.71 percent) was significantly greater than for occupied units (0.53 percent).

- As in 1990, the 2000 coverage for housing units not occupied by owners was not significantly different than for those occupied by owners. The net undercount for owner occupied housing units was 0.12 percent in 2000 and 0.37 percent in 1990. The net undercount for housing units not occupied by owners was 0.57 percent in 2000 and 0.80 percent in 1990.

- The net coverage of housing units in small multi-unit structures (2 to 9 housing units) was significantly better in 2000 (-0.17 percent net undercount) than in 1990 (2.25 percent net undercount). The net overcount of 0.17 percent was not significantly different from zero.

- The Census Bureau overcounted occupied housing units in small multi-unit structures (-1.30 percent) in 2000, but undercounted (2.11 percent) them in 1990.

- The size of the metropolitan statistical area did not impact coverage of housing units in mailout/mailback areas. For occupied housing units, the Census Bureau found no significant differences between the net undercounts for mailout/mailback areas in small (0.53 percent), medium (0.30 percent), or large (0.11 percent) metropolitan areas versus all other types of enumeration areas (0.22 percent).

As Table 7 shows, the 2000 percent of E-sample erroneously enumerated housing units was slightly better than the 1990 percent. The difference of 0.53 percentage point was statistically significant. The percent not matched was not significantly different (3.62 percent in 2000 vs. 3.57 percent in 1990). Comparisons were made but they should be used with caution. The search areas were not the same for the 1990 and 2000 Housing Unit Coverage Studies.[20]

Table 7: National Housing Unit Coverage Estimates (standard error)

	2000 (in percent)	**1990** (in percent)
Net Undercount	0.61 (0.16)	0.96 (0.24)
P-sample Nonmatches	3.62 (0.15)	3.57 (0.20)
E-sample Erroneous enumerations	2.31 (0.11)	2.84 (0.20)

[20] In 1990 the search area was the sample block cluster and surrounding rings of blocks. The surrounding blocks consisted of one ring for urban areas, two rings for suburban areas, and a larger area for the most rural areas. In 2000 the search area was only one ring of surrounding blocks for all areas and the search was targeted to certain clusters.

Barrett, Beaghen, Smith, and Burcham (2003) also classified the erroneous enumerations by type of erroneous enumeration. The types of erroneous enumerations are geocoding errors, duplicates, and not a housing unit.[21] More than half (57.0 percent) of the erroneous enumerations in 2000 were because they did not exist as housing units in the search area on census day. In 1990, 37.3 percent of the erroneous enumerations were classified as not a housing unit and 33.4 percent of the erroneous enumerations were duplicates. The type of erroneous enumerations in occupied and vacant housing units were examined. Of the vacant housing units, 66.0 percent of the erroneous enumerations were classified as not a housing unit. Of occupied housing units, the largest percentage of erroneous enumerations was for the duplicated housing units (40.7 percent).

Correctly enumerating vacant units continues to be a challenge. Estimates of net undercoverage, P-sample nonmatches, and E-sample erroneous enumerations for vacant units were significantly greater than for occupied housing units. Our estimates attributed almost 75 percent of the vacant erroneous enumerations to those classified as not housing units. The Census Bureau had a difficult time deciding whether an address identified a housing unit when no one lived there. A proxy provides information about vacant units or the Census Bureau bases the determination of vacancy status on observation from the field staff. The proxy respondent (or the observation of the field staff) may not be sufficiently knowledgeable, especially about vacant boarded up units and units unfit for habitation. Confusion as to whether to include or to delete these types of vacant units from the census inventory still exists.

Small multi-units (two to nine housing units at the basic street address) remain problematic. Although net coverage of housing units in small multi-units improved over 1990, small multi-units had the highest percent of P-sample housing unit nonmatches and E-sample housing unit erroneous enumerations among the other sizes of structures.

In future censuses the Census Bureau could customize address list building operations and/or census coverage improvement operations to target small multi-unit structures with two to nine housing units and vacant units to improve coverage. Clear instructions and training on what units meet the housing unit definition may minimize confusion of what units to include or delete from the census address list.

Jones (Report 0.10, 2003) examined census housing unit duplication as measured by the A.C.E. Duplication for these coverage measurement processes was the amount of duplication within the search area. Duplication within the entire country was not measured by these coverage measurement processes. Table 8 shows that about 25 percent of erroneous enumerations were duplicates, a decrease compared to the 1990 Census. The search areas were different in the 1990 and 2000 Housing Unit Coverage Studies as described in the footnote on the previous page. Comparisons should be used with caution.

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[21] Not a housing unit can be nonresidential or did not exist as a housing unit in the search area. A housing unit identified as not being found within the search area may have existed as a housing unit outside the search area.

Table 8: Overall Percent E-Sample Housing Unit Duplication

Year	Percent of Erroneous Enumerations that were duplicates	Percent of E-sample housing units that were Erroneous Enumerations	Percent of E-sample housing units that were duplicates	Estimated number of census duplicates
1990	33.4	2.8	0.95	971,505
2000	24.8	2.3	0.57	660,656

Jones also found:

- More housing unit duplication in small cities and rural areas.
- More housing unit duplication among units in small multi-unit structures than among single unit structures.
- More housing unit duplication among vacant units than among occupied units. Single units are more frequently duplicated when they are vacant.
- A relatively higher housing unit duplication percentage on American Indian reservations.
- Duplicate addresses referring to the same housing unit were seldom identical.

Jones' evaluation suggests the following for the 2010 census:

- Duplicate search and unduplication efforts should target small cities and rural areas, multi-unit structures in small cities and non-mailout/mailback areas, and small multi-unit structures in the large and medium sized cities.
- Attempts should be made to improve the recording of all address information for the rural areas that are not mailout and mailback.

4.2 Conflicting Households

Liu, Feldpausch, and Smith (2002) examined conflicting households identified after completing all person matching and housing unit matching. A conflicting household refers to the households at a matched, non-vacant address or individual housing unit, where the A.C.E. household and census household do not contain any matched or possibly matched people. The A.C.E. sample found 4,369 unweighted conflicting household addresses. Persons in these conflicting households accounted for 1.2 percent of the P sample and 1.3 percent of the E sample.

The census household was more likely to contain errors than the A.C.E. household when households were conflicting. This conclusion is based on the errors measured by whether the people should have been included in each household. An E-sample person determined to be erroneous and a P-sample person determined to be not a resident of the household on Census Day are both errors. In conflicting households, the E sample coded a higher percent of people as confirmed erroneous enumerations than the P sample coded as confirmed nonresidents (26.9 percent vs. 5.1 percent).

Looking at the people with unresolved residence or enumeration status, there was a high degree of uncertainty in conflicting households.

- The P sample had a higher percent of people with unresolved status than the E sample had (30.4 percent vs. 26.3 percent);

- People from conflicting households had a significantly higher unresolved rate (30.4 percent for the P sample and 26.3 percent for the E sample) than people in matched (1.8 and 1.5 percent respectively) and not matched (3.7 and 10.8 percent) housing units.

- Including imputation for unresolved residence and enumeration status, the Census Bureau estimated a larger number of E-sample erroneous enumerations than nonresidents among the P sample (1,355,026 vs. 436,900).

Among the conflicting household addresses,[22]

- The Census Bureau found more E-sample whole household erroneous enumerations (1,057) than P-sample whole household nonresidents (646);

- The Census Bureau found similar numbers of P-sample addresses of whole household unresolved (1,132) and E-sample addresses of whole household unresolved (1,070).

- The followup interviews indicated that for 1,302 addresses the P-sample household rather than the E-sample household lived at the sample address on Census Day. There were 688 addresses where the E-sample household and not the P-sample household lived at the sample address on Census Day.

Renters, Hispanics, Blacks, people of age 18-29, males of age 30-49, and households in multi-unit structures had higher rates of conflicting households than their counterparts.

[22] These numbers are from the unweighted conflicting households.

This evaluation suggests that for 2010, the Census Bureau may want to direct efforts to reduce conflicting households by:

- Probing for multiple households living at an address.

- Developing methods to ensure delivery of census forms in multi-unit apartments to the intended occupants of the apartment.

- Improving training for census and coverage measurement interviewers to identify the correct address.

4.3 Housing Unit Field Operations and Instruments

Green, Watson, Smith, Barrett, Byrne, and Spratt (2003) examined the A.C.E. housing unit phase field operations and instrument. To determine how the field operations performed and identify improvements, they focused on results from the following housing unit operations:

- Address Listing: August 1999 - December 1999
  The Address Listing recorded information for all housing units within the sample of block clusters in Independent Listing Books.

- Initial Housing Unit Followup: February 2000 - April 2000
  The Initial Housing Unit Followup occurred to get more information on housing units that could not be matched during the Initial Housing Unit Matching operation.

- Relisting: April 2000 - May 2000
  The Relisting revisited housing units and conducted a new listing operation in clusters that the original lister had listed in the wrong block.

- Targeted Extended Search 2: January 2001 - April 2001
  The Census Bureau performed the second Targeted Extended Search to ascertain if some of the housing units determined to not exist as housing units on Census Day actually existed nearby as housing units outside the cluster.

- Final Housing Unit Followup: March 2001 - May 2001
  Housing units that were added to or deleted from the inventory of housing units since January 2000 were processed and the results were then used for housing unit estimation.

Address Listing was more successful in mailout/mailback areas because those areas had more city style addresses. Rural areas are more difficult to list accurately. The housing unit followup of the A.C.E. housing units identified housing units that should not have been listed in the sample areas because of geocoding error or they were not housing units on Census Day. One reason the followup was necessary was because the Census Bureau listed housing units under

construction and future construction when the Census Bureau listed A.C.E. housing units between August and December 1999. Relisting operations were undertaken for a block cluster with 80 percent or more of the housing units geocoded incorrectly. The listing of housing units for the P sample needed to be as complete as possible. Less than one percent of the clusters were relisted.

The second Targeted Extended Search operation provided evidence that there were some housing units classified as erroneous enumerations during the housing unit followup that were actually geocoding errors.

Results from comparisons of Initial and Final Housing Unit Followup interviewer response patterns verified suspicions that some questions were not being understood by the interviewers during the initial phase. Green et. al. recommend that for future applications the Census Bureau give as much testing attention to the interviewers' instruments as the Census Bureau does to the instruments used by respondents. In particular, the Census Bureau should conduct cognitive testing on future followup instruments.

5. Conclusion and Recommendations

The 2000 A.C.E. was well thought out and well designed, but it encountered some unexpected problems. These problems resulted in the final estimates produced from the March 2001 A.C.E. being declared unacceptable for apportionment purposes. The A.C.E. required a precise and accurate measurement of residence and enumeration status. Assuming the Census Bureau continues to use a coverage measurement survey to measure undercount in the future, we have some recommendations. More research is needed to design interview instruments to accurately identify people who should be counted in the household. Living situations have become more complex with multiple residences and mobility. More research is needed to understand sources of error, such as recall error and lack of knowledge on the part of proxy respondents, and to devise questions and categories that can be reliably and accurately reported. Intensive questionnaire design research and testing are needed to improve the quality of coverage measurements. (Martin, Fay, and Krejsa, 2002a and 2002b.) Designs robust to this error should also be investigated.

The complicated, overlapping, and counterintuitive census residence rules make it difficult to measure coverage accurately. The rules need to be simplified and empirically evaluated.

The Census Bureau will continue to research issues discovered with the A.C.E., particularly the duplicates and their estimation or detection. This research may lead to development of methods to improve future population estimates that combine information from the census, A.C.E., and the A.C.E. evaluations, including the Person Duplication Studies.

Both census taking and coverage measurement evolve and improve with each census. The Census 2000 will help refine both census and coverage measurement processes for future

censuses. We combined recommendations for 2010 into four categories - data collection, survey design, estimation, and coverage measurement evaluations.

5.1 Data Collection

Review the residence rules and critical definitions. The Census Bureau should create simpler rules that can be understood by everyone as they fill out their census forms and as they are applied in the field. The rules should be consistent with the ways people think about their residence. The difficulty identifying erroneous enumerations in the 2000 A.C.E. may have been due to the census residence rules.

Improve methods to identify duplicates and remove them from the census. People with multiple residences or other places where they can be counted can cause duplication. We need to identify which duplicates should be removed.

Continually improve interview instruments used in coverage measurement and the evaluation. The Census Bureau needs instrument development and testing on conceptual, recall, and comprehension issues for group quarters residence, multiple residence reporting, and mover reporting.

Reduce expensive, time consuming and labor-intensive clerical coding operations. Accurate classifications should be produced by standardized questions in the interview instrument, with a reduced need for interpretation by the matchers. The coding of responses should be consistent and have data editing.

Redesign the housing unit followup instrument. The Census Bureau discovered P-sample housing unit geocoding errors after person matching. Therefore, the followup of P-sample housing unit nonmatches did not identify housing units listed as being in the block cluster in error.

5.2 Survey Design

Think more about how movers are treated. In 2000 the Census Bureau used “Procedure C” with a few exceptions where we used “Procedure A”. “Procedure C” matches the nonmovers and outmovers at the Census Day address and within the search area. “Procedure C” rather than “Procedure B” was used in 2000 because it is easier to match within the search area. One problem with “Procedure C” was interviews with whole households of outmovers were proxy interviews. “Procedure B” was used in 1990 where the nonmovers were matched to the Census Day address and the search area. The inmovers were matched to their Census Day address requiring collecting the Census Day address for the inmover, obtaining the census geography for the address, and matching to that address and it’s surrounding blocks. This inmover matching was time consuming because the census questionnaires were printed from microfilm for clerical matching. The entire mover matching process could be improved in 2010 since names are

captured for the entire country. A streamlined process that is fast and easy would need to be developed for geocoding and matching for the inmovers in 2010. The Census Bureau may want to consider using "Procedure B" in the future.

Consider making the search area the entire country. Then, census correctly enumerates someone by counting them once in the country. An erroneous enumeration occurs when a census person is duplicated. This design requires a computer matching algorithm that accurately matches the P-sample people to all census enumerations in the country and identifies census duplicates. A followup interview would be needed to identify E-sample not matched people who were erroneously enumerated because they died before Census Day, were born after Census Day, or did not live within the United States on Census Day. An advantage of the search area being the entire country is making the problem with residence rules not a factor since a person is not erroneously enumerated when counted at the wrong location according to census residence rules.

Alternatively, the search area could be the state or other smaller area. Computer matching within a smaller area would be easier than matching in the entire country. The followup interview would also need to identify E-sample not matched people who were erroneously enumerated within the search area because they did not live within the search area on Census Day.

Another design that exploits an expanded search area is any address matching. In any address matching the person interview obtains all addresses where the P-sample people could be enumerated. The research should determine if a nonhousehold member can provide these addresses. Analogously, this design identifies duplicates in the census by asking people not matched in the E sample for all places where they could be enumerated, which requires geocoding and searching these addresses. This difficult process of geocoding and searching the addresses was conducted for matching movers to their Census Day address in the 1990 PES. For 2010 the process would need to be made more efficient. Improved computer technology should make mover matching more efficient. The Census Bureau could also consider collecting alternate addresses on the census questionnaire.

The design for 2010 could combine the automated and any address matching.

5.3 Estimation

Consider a sampling plan flexible enough to implement either a state or national design. Build a plan into the weight trimming procedure that includes a threshold criterion. Impute missing characteristics using the same procedures in the census, especially for the E sample. Consider linking the P- and E-sample files to use in resolving missing data. When gathering information used to assign probabilities for unresolved person status, use information pertaining to the interview and less demographic information.

Use generalized DSEs, a modeling approach that computes the probability of capture based on demographic characteristics. Use both the P and E sample when developing the

post-stratification plans. Re-evaluate whether to correct for correlation bias in the DSEs. Consider whether the use of complex variance methods would be more beneficial in production or in an evaluation of the production variances.

The Census Bureau should continue to use DA as a coverage evaluation tool. For the 2010 Census, the Census Bureau should also investigate ways to measure uncertainty in the DA estimates of undercount and to expand DA estimate to more race/ethnicity groups.

5.4 Coverage Measurement Evaluations

The Census Bureau should continue to develop programs to evaluate the coverage person estimation and consider how best to synthesize individual measured errors. The Census Bureau should consider evaluating the housing unit coverage estimates.

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Appendix

Inconsistencies in race classifications

The race categories in the DA estimates largely reflect the race assigned the particular administrative records at the time of the event (birth, death, or enrollment in Medicare). The DA estimates of the net undercount are biased to the extent that people who are classified as a particular race in DA (e.g., Black) reported a different race in the census.

The effect of the new "mark one or more" instruction for the Census 2000 question on race complicates the traditional comparison of DA estimates by race with census race tabulations. In fact, the Census 2000 tabulations do not include a category "Black" that is comparable to 1990 or earlier census tabulations. Tabulations for the Black population for 2000 contain tabulations of the number of people who reported Black only and tabulations of the number who reported Black whether or not they reported other races as well.

To deal with the reporting more than one race, we present alternative DA estimates of census undercount using two models: (1) Model 1 compares the 2000 DA estimates for Blacks with Census 2000 tabulations for people who reported Black only, and (2) Model 2 compares the 2000 DA estimates for Blacks with Census 2000 tabulations for people who reported Black whether or not they reported any other race. At the youngest ages, the differences between the two models are the greatest. The tables and figures show the averages of the two model estimates for comparison with the historical DA estimates and 2000 A.C.E. results. These averages are not necessarily the best point estimates; research on the detailed Census 2000 race and ethnicity data to conducted later this year may provide a basis for determining at which point along the Model 1 to Model 2 range of census race tabulations the DA estimate might best be compared.

A final inconsistency affects race comparisons of the DA and A.C.E. estimates. In 1990, the 9.8 million people (mainly Hispanics) who reported their race as "Other Race-Not Specified" in the census were redistributed (for DA estimation) to the categories White; Black; American Indian, Eskimo, or Aleut; and Asian or Pacific Islander so that the census counts were consistent with the race categories of the historical demographic estimates. A similar modification to make the census race categories more comparable with the historical demographic data was again used in 2000 for the DA estimation.

The inconsistencies in the race data place even more importance on the use of sex ratios for making inferences about coverage by racial categories in Census 2000. Specially, to the extent that the inconsistencies in reporting and the numbers marking more than one race are about the same for men and women, the inconsistencies will tend to cancel out in the calculation of sex ratios. We found this assumption held true: in Census 2002, the sex ratios for people who reported Black only are nearly identical to the sex ratios for people who reported Black whether or not they reported other races. (Robinson, 2001.)